The
HOW AND WHY
Wonder Book of
COMMUNICATIONS

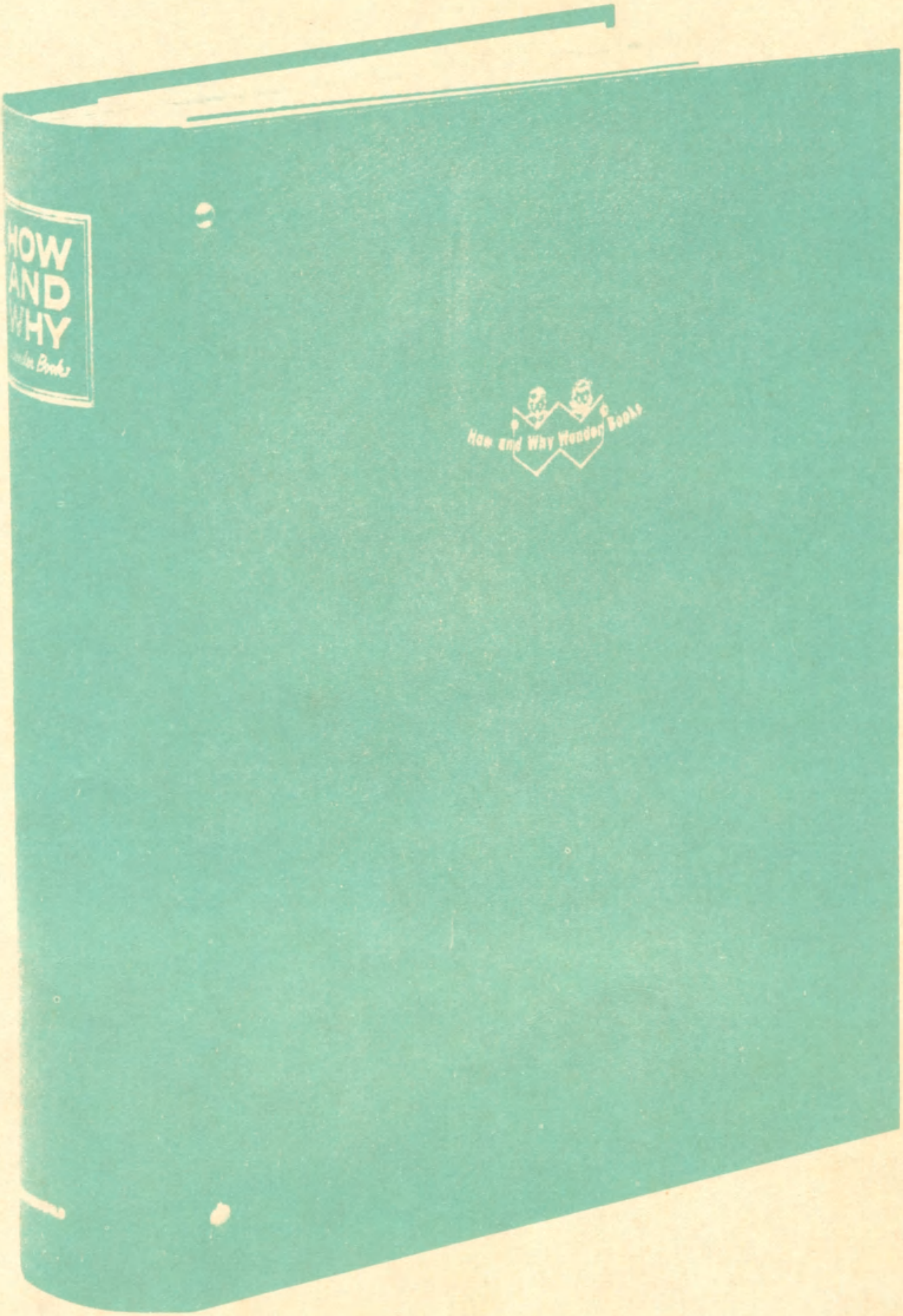
50p

0 552 86558 3

NEW! A collector's binder to hold

your HOW AND WHY Books

This new How and Why collector's binder holds twelve titles: a wonderful way to build your own reference library! It is available from the publishers of How and Why books for £2.00 Supplies are limited so send for yours now.



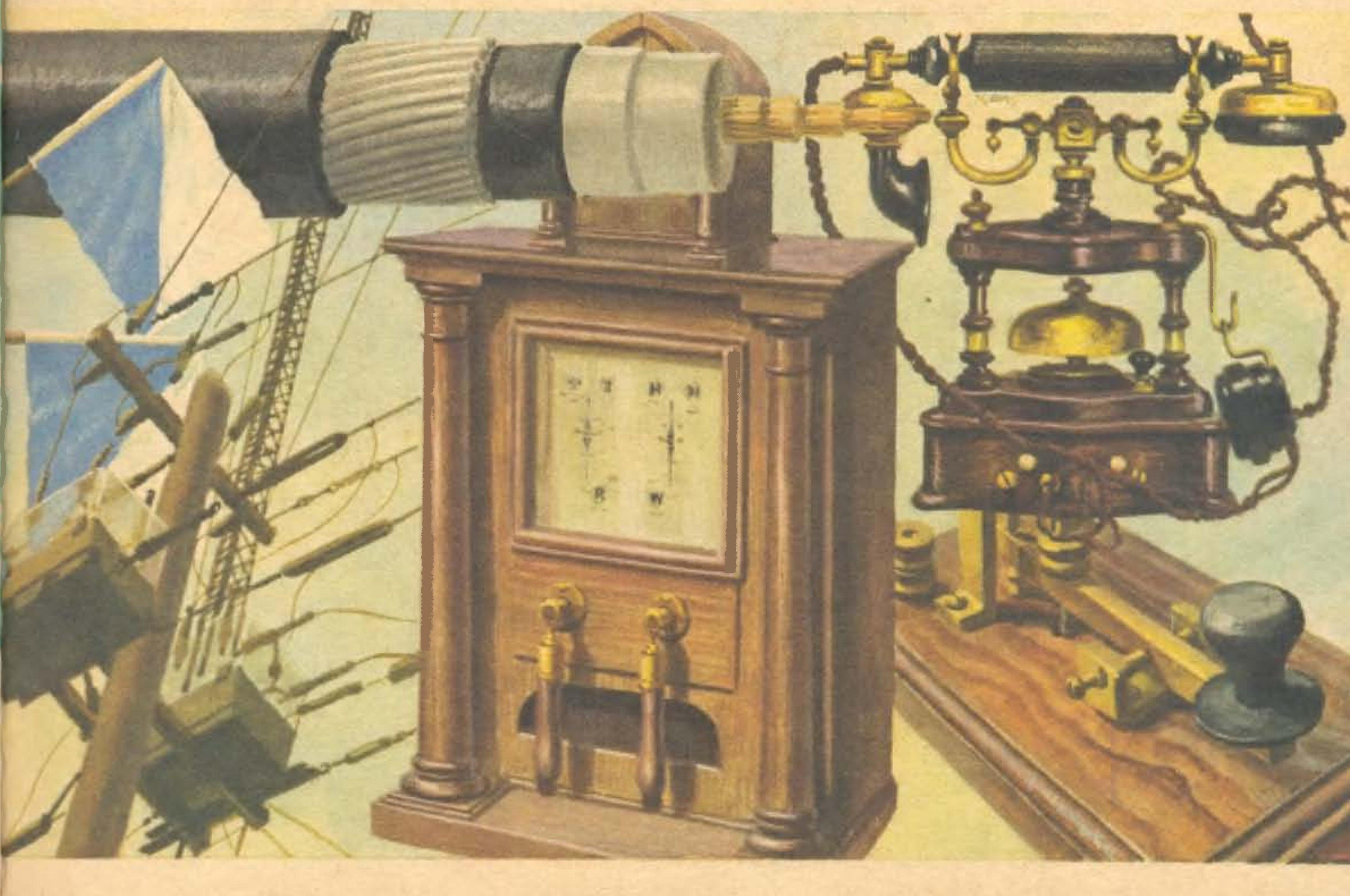
Transworld Publishers Limited, Cash Sales Dept., P.O. Box 11,
Falmouth, Cornwall. Plus 50p Postage and Packing.

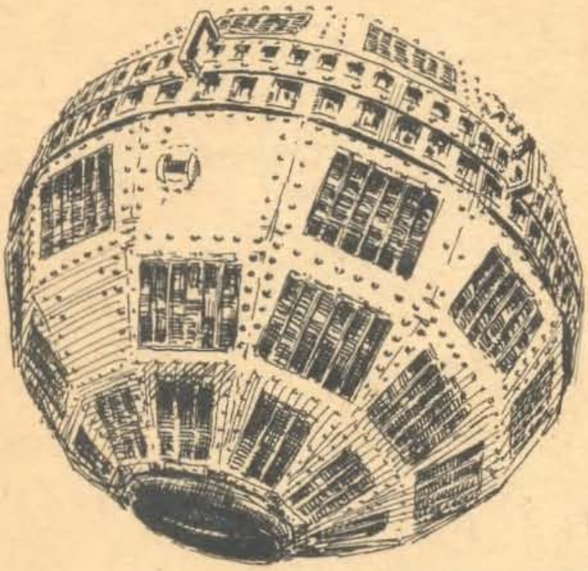
THE HOW AND WHY WONDER BOOK OF

COMMUNICATIONS

Written by WILLIAM BOWEN-DAVIES
Illustrated by EDWARD MORTELMANS

TRANSWORLD PUBLISHERS : LONDON





INTRODUCTION

The How and Why Wonder Book of Communications is not intended as a technical book explaining how complicated apparatus works. It does show you how, for example, radios, telegraph systems and televisions work, but it mainly looks at the history of how different forms of communication came about and some of the men responsible for them.

Communication here is used in the sense of man speaking to man, and not in the wider interpretation including such subjects as transport and language, and the expression of man's thoughts.

Acknowledgements—Mullard Ltd; The Marconi Company Ltd; Hughes Aircraft; The Post Office.

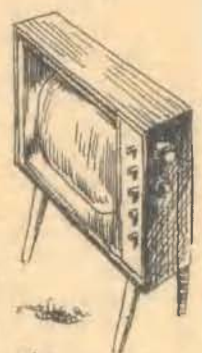
Originally published in Great Britain by Transworld Publishers Ltd.

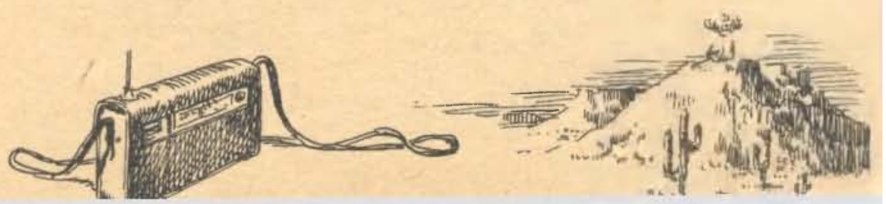
PRINTING HISTORY

Transworld edition published 1973
Transworld edition reprinted 1977

The How and Why Wonder Book Series is originated and published in the U.S.A. by Grosset and Dunlap Inc., a National General Company.
Published by Transworld Publishers Ltd., Century House, 61/63 Uxbridge Road, Ealing, London W.5 5SA.
Printed by Purnell & Sons Ltd., Paulton (Bristol) and London.

CONTENTS





Communication has always been essential in times of war. A runner brought the news of the Marathon victory; Persian soldiers sent messages by shouting to one another; and Alexander used a horn to communicate with his army.

Why Communicate?

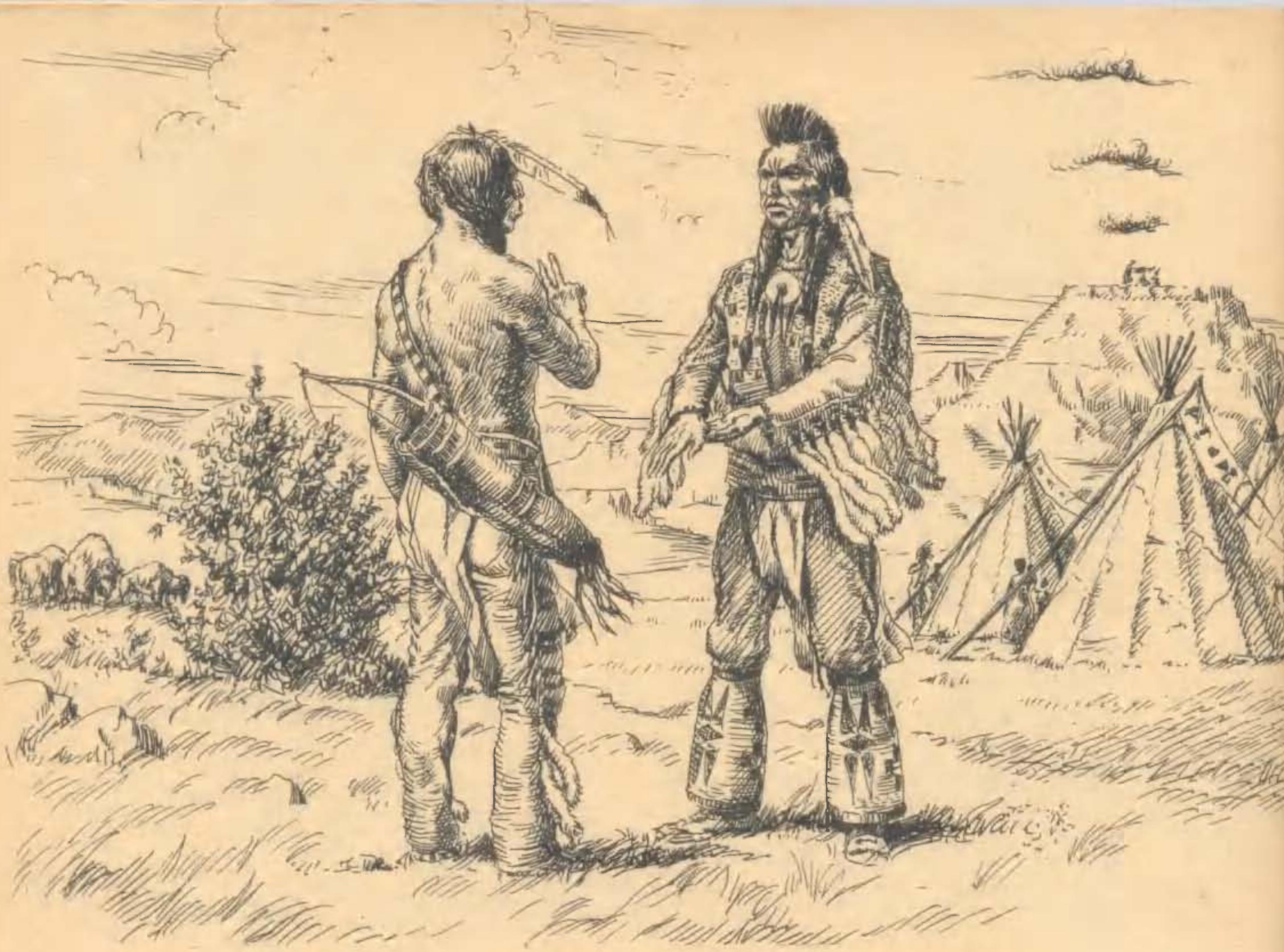
Communication through the ages has been the transmission of information between individuals by sound, touch or sight. A man communicates with his fellows for a number of reasons. He communicates to express his needs, his opinions, his feelings about himself, his surroundings and other people around him. He feels not only for himself but for his fellows.

How did messages evolve?

From early times man has striven to increase his range of communication by different methods, with and without various mechanical aids. In this way, communication gradually became more rapid, travelling over greater distances, and the use of the written word for messages and history (the passing on

of information from one century to another) finally evolved. In time of peace, communication has advanced through the necessities of commerce, dealing with disasters, and seeking urgent medical help. All through history messages have also played a vital role during times of war. Battles have been won or lost through the success or failure of urgent information being given at the right quarter at the correct time. In 490 B.C. Pheidippides ran 150 miles to get help from the Spartans for the Athenians who were fighting the Persians. Another runner, with news of the victory at Marathon, died on the steps of the Acropolis, after delivering the message. From this battle we get the word *marathon* describing a long race which is used in the Olympics and other races today.

The Persians are reputed to have used a vocal method of signalling by choosing men with powerful voices and stationing them on high platforms about a mile apart. Messages could thus be sent over a specified area by being shouted from one man to another, using their cupped hands as an aid to their vocal chords. Alexander the Great used a large horn in his army for communicating messages over a distance, perhaps the forerunner of the megaphone perfected electronically many years later.



Red Indians used arm and hand movements to "talk" when they wanted to remain silent. For sending messages over long distances they used smoke signals.

Why do people "talk" with their hands?

Some people communicate with their hands as well as with their voice by emphasizing their speech by gestures. Some Red Indian tribes are known to have been able to "talk" with their arm and hand movements. This method would be used when stalking an enemy or game, when the braves could communicate with one another without disturbing their quarry. Hand sign language is in daily use as a means of communication with, and between, those who are deaf and dumb.

What sound instruments can be used for communicating?

As man found he wanted to communicate at greater distances. so he turned to more mechanical means to help him do so. The Red Indians, for example, used smoke signals, and a drum or tom-tom. The tom-tom was also used in central Africa and was made from animal skin which was stretched over an empty container. The beating of this drum by the natives could be repeated from one village to another to relay messages over a considerable distance. The

whistle has been used by many different types of people, including policemen calling for assistance or as a warning; and referees to govern the start and halt of play in football. Another sound instrument is the horn which is well known as an early form of communicating out in the open. Still used for hunting in England when the fox is sighted, it had many other uses in the past including that for alarm at the approach of a foe. This led to the trumpet and bugle calls which controlled armies in battle over many centuries. Speaking tubes have been used in offices and aboard ships. The end of each tube, usually held in a wall-bracket, contained a whistle, which the caller would remove to blow down the tube and operate the whistle at the other end and attract the attention of the person he wished to converse with. The telephone has of course largely replaced the speaking tube, though it is still used at sea in an emergency, when the power supply has failed and communication is vital between the bridge, wireless-room and engine-room.

Africans in the jungle make tom-toms with stretched skins, and beat on them to send messages.

Carrier pigeons have been used from very early times, and they were particularly valuable in the two World Wars when bombardments prevented any other method of sending information.

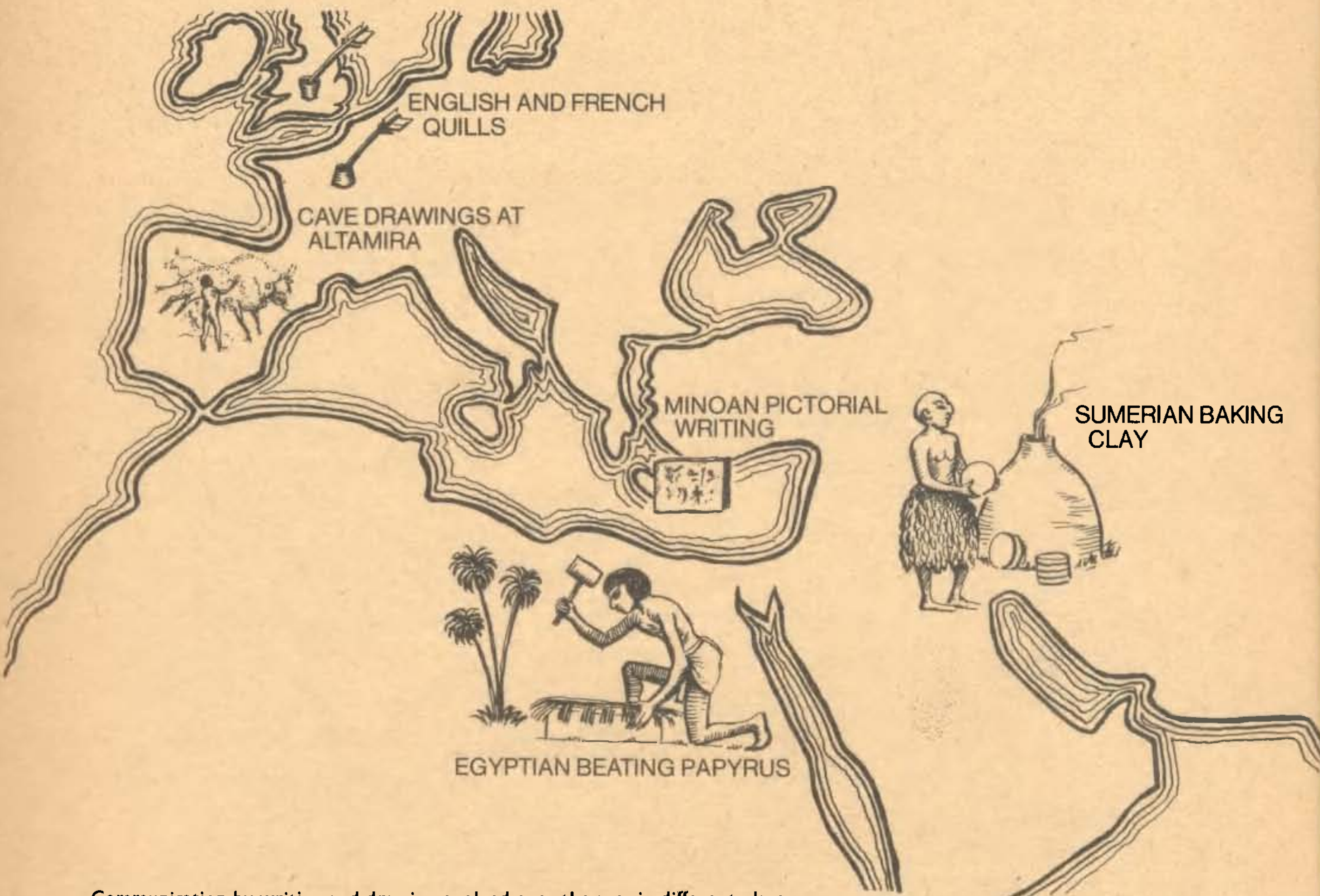
Why were pigeons used for communicating?

To help him in his quest for quicker communication, man has sometimes turned to animals to aid him. In early times the Persians used relays of messengers on horseback. Pigeons have a wonderful sense of direction and by training and attaching messages to them (usually to their legs), great use was made of their ability to fly to a given point. The garrison of Modena used them to call assistance when they were besieged by Mark Antony in 43 B.C. They were used in Syria and Mesopotamia during the Middle Ages and finally their use extended to Western Europe. In 1840 Hawes News Agency were operating a pigeon service between London and Paris. At the beginning of the First World War the French handed over 15 pigeons to the British Expeditionary Force who eventually, through the Signal Service, expanded the use of pigeons as messenger carriers until towards the end of the war there were over 20,000 birds for operational service, in the forward lines and elsewhere. They were exceptionally useful in action, especially during advances when other forms of communication proved unsure. When even underground telegraph cables were shattered by heavy gunfire, wireless signals could be intercepted, and the ground was too rough going for a dispatch rider, what other form of communication bettered the safe flight of a pigeon? Dispatch riders, used in both world wars, and still much in evidence today, were equipped with powerful motorcycles: swift and reliable, they formed a vital link carrying dispatches from one area of operation to another. They could carry such things as maps and other bulky papers, which pigeons could not carry. Their smartness and reliability earned them their good reputation in both world wars.

Communication by Written Word

How did the written word come about?

Through history and records man has learnt about the past. Without the early writings of clever men like Aristotle, and other great philosophers, education would possibly not be what it is today. Man's thirst for knowledge increased as more was made available for him to learn. As early as 3500 B.C. the Sumerians produced writings on baked clay. Five hundred years later the Egyptians had perfected hieratic writing. At the same time, during the early Minoan Age in Crete, pictorial writing in copper, silver and gold was used. In 781 B.C. the Chinese recorded an eclipse and the art of writing was introduced in India in 600 B.C. Historical records, such as the cave drawings by Stone Age Man at Altamira in Spain, were a form of communication down through the ages telling us something of the thoughts of primeval man. Papyrus was used by the early Egyptians for writing on and was obtained by criss-crossing and beating out the stems of the papyrus plant.



Communication by writing and drawing evolved over the ages in different places

Quills were sharpened by knives to make pens—hence the word "penknife".

Monks produced beautifully decorated manuscripts by hand before printing came into use.

T'sai Lun, a Chinese, invented paper just prior to the Chinese Era, and the Moors brought it to Europe around 800 A.D. Ink used by Greeks and Romans was from cuttlefish and their pens were usually from hollow reeds and bamboos. Quill pens date back as far as the 7th century. The end of the quill was sharpened with a knife which gave us the name "penknife". The quills were taken from geese wings.

In 1780 steel pens made their appearance. At first they were too expensive to be popular until machines turned them out forty years later. In 1884 L. E. Waterman patented the first fountain pen. Fountain pens were of course ultimately followed by the ball point pen which is now mass produced at a very economical price. The Chinese calligraphers still use a brush for lettering as do most commercial artists for lettering book jackets and advertisements. Lead pencils date back as far as the 16th century, but reliable ones were produced in France in 1795 by M. Conte. The Conte pencil is well known to artists to this day.

Who was William Caxton?

Eventually people got tired of writing by hand and looked for an easier and quicker method. Writing a letter was one thing but what of producing a book or pamphlets? The monks no doubt enjoyed their laboured task of illuminating those magnificent bibles in their monasteries, but in the outside world men were impatient for progress and turned to a machine of some sort that would simplify and hasten their task. Printing is thought to have appeared in Holland about 1445. The

Mail was transported by post boys who blew a horn to herald their approach.

An early printing press at work.

first British printer William Caxton set up a printing press in Westminster in 1477. Power presses were invented in James Watt's time and in 1814 two were made for The Times newspaper by the German Friedrich Konig. Rotary presses, where the printing matter rotated on a cylinder as compared to being on a flat surface as in the earlier type-setting, came into being during the middle of the 19th century. The type, however, was still set by hand. Machines to set the type did not appear until Ottmar Mergenthaler produced them during the 19th century. Printing produced books, handbills, pamphlets, almanacs and newspapers. A more personal machine, the typewriter, was invented by Christopher Shales around 1868, which became the Remington typewriter in 1878.

How was the written word sent in 1784?

Having written correspondence, how was it to be transported? The first mail coach appeared on 2 August 1784, running from Bristol to London, the 116 mile journey taking 17 hours. This time was later to be speeded up to over 10 miles per hour when improvements were made to the roads. The advent of the mail coach is said to have been the idea of John Palmer. Before this time mail was entrusted to post boys mounted on horse-back. The mail bag was strapped to their backs and they heralded their approach by means of blowing a horn. John Palmer felt that the mail would be safer in the hands of armed guards in a stage coach, and he made the suggestion to William Pitt, then Chancellor of the Exchequer.

Mail being sorted en route by rail.

How is letter sorting and delivery speeded up?

In Great Britain today, about 28 million of the letters collected from post boxes all over the country have to be taken to a centre where they are sorted to the different areas where they are to be dispatched. We have all seen, at some time or other, the mail bags in which letters are placed and transported from sorting offices and dispatched to the railway stations for transport to other main offices. What we most likely have not seen is the British Rail trains which are equipped as moving post offices where further sorting is carried out while the train speeds on its way. In London, the post offices have their own underground rail system where mail can be quickly transported between sorting offices and the main line stations.

With the advent of micro-photography, the written word could be photographed and reduced in size to be stored away for record purposes, saving a good deal of space. This principle was used to great advantage during the Second World War, when it was important to keep up the morale of

fighting men abroad by ensuring that they had written contact with their friends and families at home. The Airgraph System whereby the serviceman could write his letter on a single sheet of paper, which was photographed, reduced in size, and flown home by air mail to the relatives, was a great boon to him as to his family. It might be a matter of years before he saw them again, but at least they knew he was well at the time of writing.

The Air Mail system has greatly speeded up the dispatch of letters overseas. The first air mail in England was flown between Hendon and Windsor in September 1911. Even with the speed of air mail it still takes time to get a message across any distance. Any urgency calls for speed. The ideal situation is the instant reception of a message urgently transmitted. In order to achieve this man invented telegraphy in many forms.

The first air mail in England was flown in 1911 between Hendon and Windsor.

Visual Telegraphy

What does "Telegraphy" mean?

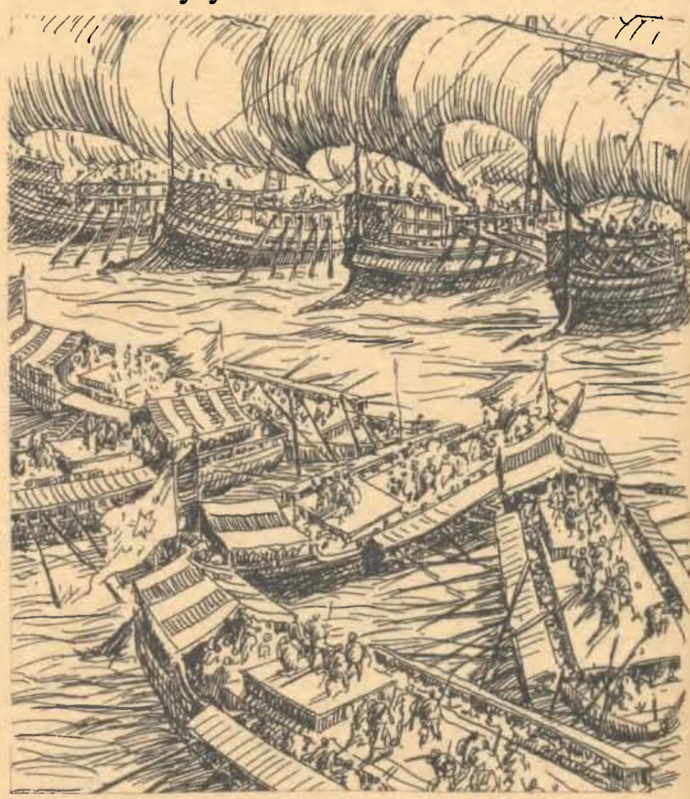
The word telegraphy or telegraph is derived from two Greek words—"Tele" meaning "far" and "Graphos" meaning "written". Thus telegraphy could be interpreted as a written message, or signal, being sent over a distance. In 150 B.C. the Greeks used a signalling system where lighted torches were placed between the gaps of two walls. The gaps in one wall represented the line of the code they were using, and the gaps in the second wall represented the letter in that line. In this way the letters of the message were spelt out by torchlight. Fire was another means of signalling. At the time of the invasion by the Spanish Armada, beacons were placed around the English coastline to warn inhabitants of the approach of the Spanish ships. This type of telegraphy was known as optical or visual telegraphy.

At the battle of Salamis, in 480 B.C., the Greek ships were outnumbered by the Persians and things looked bad for the Greeks. An unexpected signal from their flagship ordering all the ships to turn and face the Persians who were encircling them, surprised the Persians and threw them into confusion.

The use of flags later spread to Europe. They were used by the Romans on their military standards, and Brutus in 49 B.C. used flags on his ship which could easily be recognized.

How were windmills used to send secret messages?

In 1575 British ships set their sails to give specific meaning and fired a cannon to attract attention. Many years later, during the Second World War, partisans used a different type of sail setting for messages, that of the windmills of Holland. This way the underground movement was able to carry messages used against the German occupying forces. This was no new means of signalling for the Dutch who have used different positions of windmill sails for indicating the events of birth, marriage and death for many years.

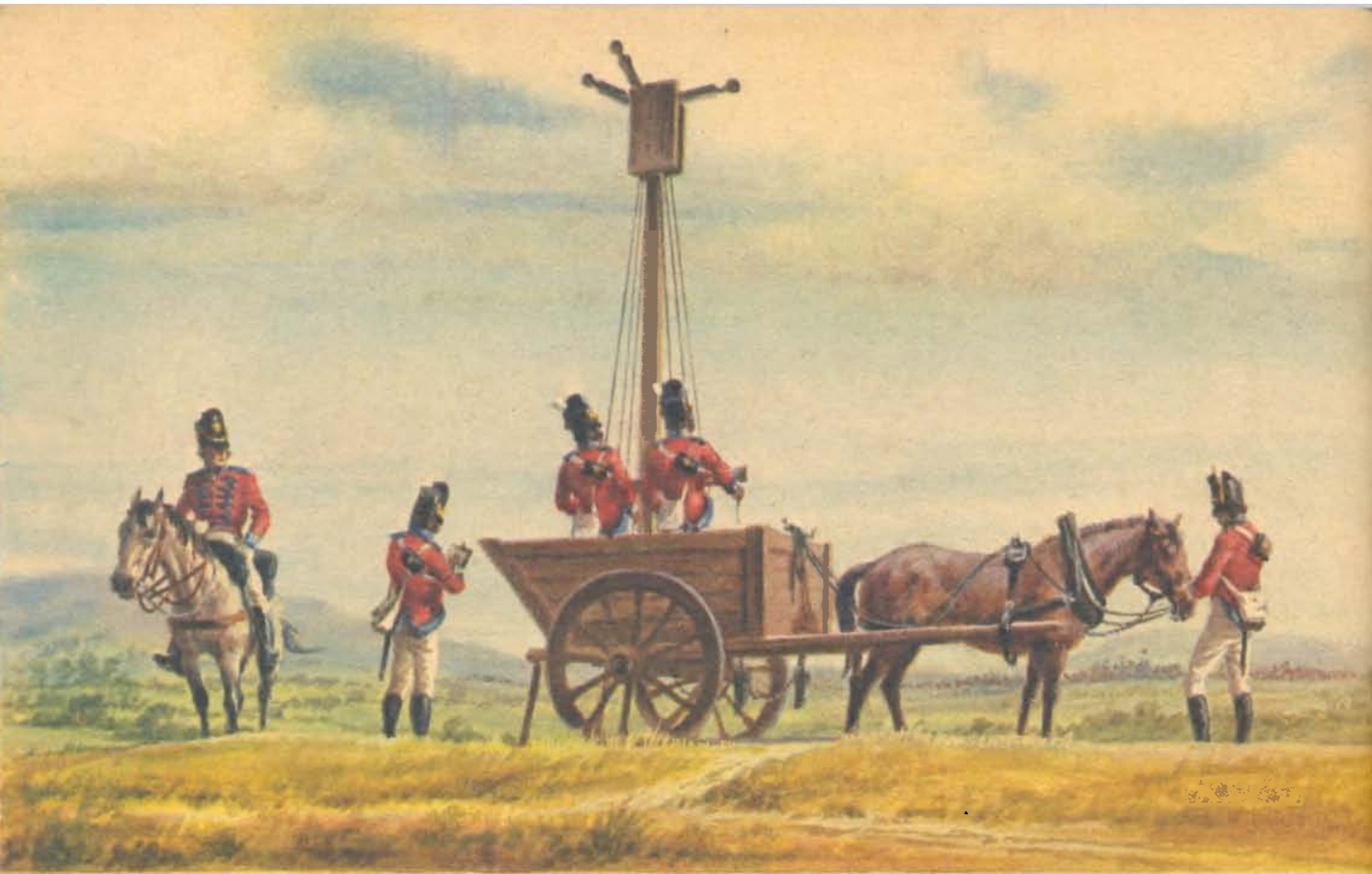


The Greeks turned defeat into victory by following orders signalled to them by their flagship.

Napoleon's soldiers operating Claude Chappe's signalling machine.

Who invented a mechanical telegraph during the French Revolution?

The year 1789 saw the beginning of the French Revolution — and an urgent need for quick communication in the campaign. Claude Chappe, a Frenchman, saw the need and with the help of his brother and others, produced a machine which was accepted by the Legislative Assembly in 1792. Set on a tower, it consisted of a central vertical beam, at the top of which was pivoted a crossbar. At each end of the crossbar two more pivoted arms were attached, one at each end. The pivoted beams were controlled by copper wires and pulleys operated by handles at the base of the machine inside the tower. As many as 196 different positions could be made with the pivoted arms giving up to that number of signals. The signal arms were constructed to minimize wind resistance and painted black for easy recognition. The signals from one tower were read from another tower by means of a telescope and a chain of stations radiated from Paris and reached out to other cities in other countries.



Gamble's six-arm semaphore was mounted on carts and used in the field by the army.

The semaphore was introduced in England in 1795 by the Rev. Lord George Murray. It consisted of a screen with six shutters which was operated to give 63 combinations. The boards were pivoted and moved by cords. The Admiralty used it to operate from London to various relay stations along the coast. A message could be sent between London and Portsmouth in a matter of minutes. John Gamble invented a six-arm semaphore at about the same time as Lord Murray invented his. This machine consisted of a vertical post with three arms either side. It was tried by the army in 1797 and employed for field use mounted on carts or coaches. Used with a telescope it had a range of five miles. Chappe's aerial telegraph system survived for forty years after his untimely death in 1805. When other scientists and inventors realized the potential of electricity as a means of improving telegraphy the days of the manually operated visual telegraph were on their way out.

How do heliographs work?

Before we pass on to electrical telegraphy let us consider visual telegraphy by reflected light. We have seen how the Greeks signalled by torches in the dark, but what of daylight signalling? We all know that by taking a simple hand mirror and catching the sun's beams directly on to it we can direct a very bright spot of light on the walls or ceiling of a room from sun shining through the window.

In 1821, a prototype heliograph was invented by Gauss. It consisted of two mirrors which were placed at right angles to each other. One mirror was used for focusing, the other for signalling. Several different types of heliograph were used for signalling in different theatres of operation. Mance's Field Telegraph employed a sighting rod in addition to the signalling mirror. Begbie's Field Telegraph used two mirrors, one as a "sun mirror" to reflect the sun on the signalling mirror, should the sun be *behind* the signaller. In addition the signalling mirror was kept static, so that it was not out of alignment with the reflected sun's rays, keying being carried out on a screen placed a few feet in front of the signalling mirror. Attached to the signalling mirror was a sighting arm with a sight to keep the reflected sun's rays in line with a hole in the screen. The reflected light could then be broken up into dots and dashes by means of a key which could be operated to admit or obstruct reflected light through the screen. All mirrors used in the apparatus, as in the case of the Mance heliograph, had a hole or circle in the centre, so the operator could focus the mirror on to the station to be signalled to. The pencil of light produced by these methods had the advantage of directing the beam where intended and so providing security against the interception of the messages by the enemy.

Visual signalling played an important part in the South African Wars. The degree of sunshine and clear atmosphere was ideally suitable in that country for visual signalling of all kinds. In clear weather, using heliographs, distances of 50 miles could be obtained without the use of binoculars. Over hilly country, distances of 100 miles were reported. Transportable semaphore was used extensively in South Africa together with flags of different size.

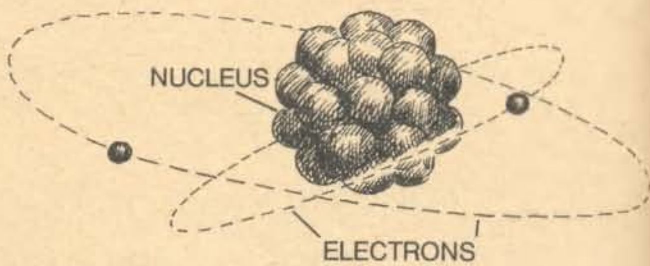
During the South African Wars British soldiers used heliographs to signal to each other.

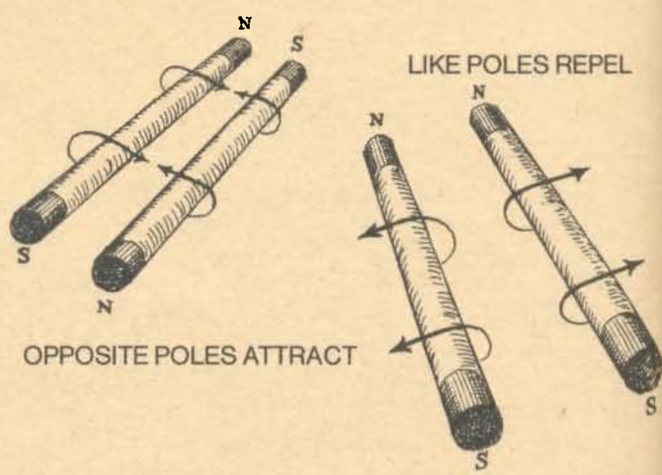
COM—B

Towards the end of the 19th century limelight lamps were used for signalling by day as well as by night, using the Morse Code. Signal lamps using shutters were employed by warships in both world wars and, during the Second World War, the Aldis lamp, with telescopic sights, was used to great advantage by signallers aboard aircraft on sea patrol and on merchant ships in convoy. Ships could communicate with aircraft as well as with other ships. The Aldis lamp was held up to the eye, focused on the object to be signalled to, and was operated by a finger trigger which deflected the light by means of a movable reflector.

Communication by Electrical Telegraphy

Those enterprising men, the Greeks, not only discovered that when pieces of amber were rubbed with material they picked up small particles, such as fibres, but also in the area of Magnesia were stones which, when placed near pieces of iron, attracted them. So it is from the Greeks that we get the name "electricity" and electron. They called amber "electron". We call the electron a unit of negative electricity. Matter we find is built up out of a number of electrons circulating about the positive nucleus, which comprises the atom. From Magnesia, we get the term magnetism, which is caused by magnets which attract metals to them. If you take a comb and pass it several times through your hair, and then immediately put it on a small piece of paper, one end of the comb will attract the paper. You have charged the comb with positive electricity. If you take two identical magnets, each with a north and south pole, and place them near together, you will find that like poles repel, whereas different poles will attract. It was through simple experiments such as these that our forefathers gradually built up discoveries which led to the use of electricity in communication and other services.





Above—the composition of an atom. Below—attraction by two dissimilar magnetic poles; repulsion by two similar magnetic poles.

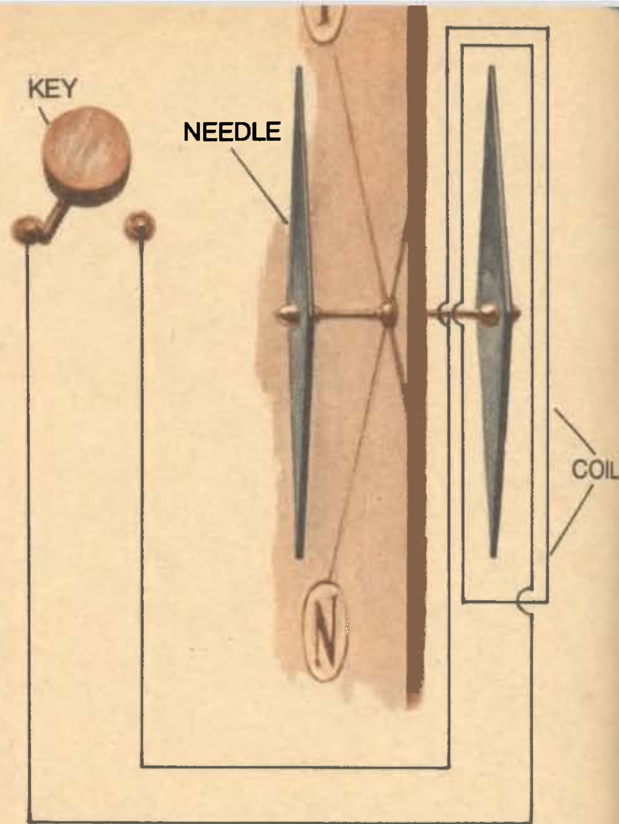
Musschenbroek's experiments enabled electricity to be stored. The apparatus was called the Leyden Jar.

What is the Leyden Jar?

At Leyden University in 1746 Pieter Van Musschenbroek found that by charging a glass jar partially filled with water, he was able to store electricity. Forerunner of the condenser storing electricity, the apparatus became known as the Leyden Jar. In England Henry Cavendish set about improving the Leyden Jar by the use of tinfoil on its inner and outer surfaces.

This system had two main problems. Firstly, the electrifying machines for charging the Leyden Jar were rather cumbersome pieces of apparatus, and secondly, the jar itself would only supply electricity for a very short time. Alessandro Volta, an Italian professor, found an answer to this by his invention of the Voltaic Pile. This was in effect the first electric battery, and was constructed of zinc and silver discs set alternately, and separated by pieces of moistened cardboard. His theory was that when you placed two dissimilar metals in contact with one another you caused an electric current to flow. To Volta went the honour of having the unit of electricity, the Volt, named after him.

In 1820, a Danish physicist by the name of Oersted proved that a magnetic needle of a compass was affected by the current passing through metal placed near it. Later this led to the invention of electro-magnets which were to prove invaluable for operating the telegraphic circuits. An electro-magnet can be produced by wrapping a coil of wire around a piece of soft iron and passing a current through that



The Cooke and Wheatstone five needle telegraph.

wire. Whether the piece of metal is in the shape of a bar magnet or a horseshoe magnet, a north and a south pole will exist at either end of the magnet. Ampere, a French physicist, with advice from Pierre Simon Laplace put forward the idea of passing a current through a number of wires, one for each letter of the alphabet, and terminating them at the receiving end with a compass needle to each wire. In this way a message could be sent. Ampere's name gave us the unit of current, the ampere (shortened to amp.).

What Russian proved Ampère's theory?

Paul von Schilling-Cannstadt, a Russian, put Ampere's idea into practice. He also took note of the discovery that a stronger current could be obtained by making the wire carrying the current in the form of a coil. His transmitter took the form of ten keys, like a piano, which could transmit ten different signals along wires to five different coils at the receiving end of his apparatus. Inside each coil was a magnetic needle which could be deflected two ways from the north-south position, depending on the direction of the current sent through it. The direction of the current was determined by which key was pressed at the transmitting end. Thus it was possible to send ten different signals. He first demonstrated his apparatus at Bonn in September 1835. A year later William Cooke, the son of an English doctor, saw some experiments by Professor Munke at Heidelberg with Von Schilling's telegraph. At Heidelberg he

experimented on the idea himself and on his return to London he spent the rest of the year working on the invention of a new telegraph, encouraged by Michael Faraday, the famous Professor of Chemistry.

How were the telegraph and the railway connected?

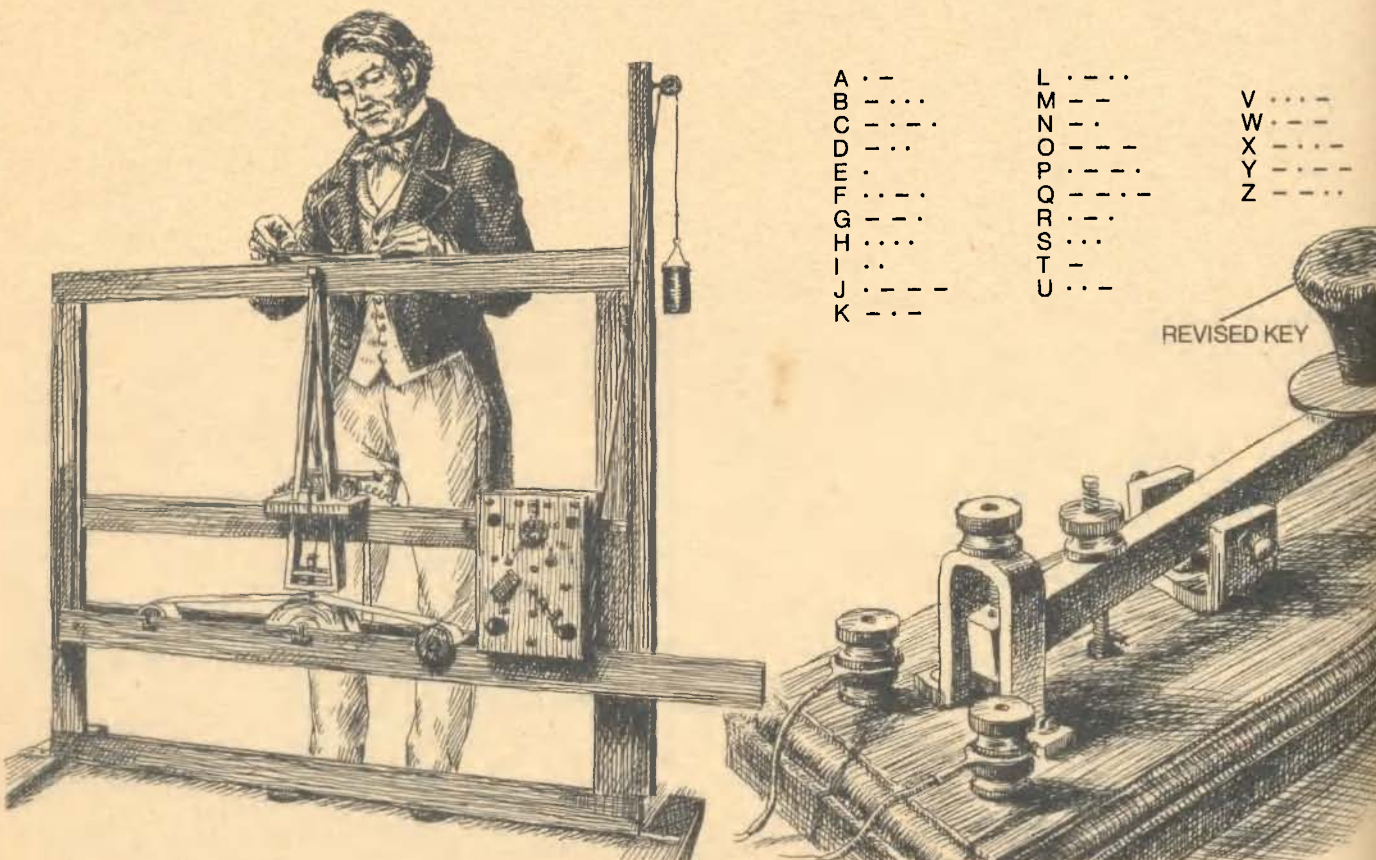
In 1837 Cooke formed a partnership with Professor Charles Wheatstone, who was also experimenting with telegraphic apparatus, and between them they applied for a patent. Robert Stephenson, Chief Engineer to the Railways, was approached and in the autumn of the same year an experimental telegraph line was laid down by Cooke between Euston and Camden Town. The following year he laid another telegraphic line between Paddington and West Drayton which was later carried on to Slough. The interesting point of this particular project was that they were now using a two needle telegraph which indicated each letter by a pre-arranged code determined by the momentary deflection of the needles. The previous five needle telegraph was so constructed that the required letters were individually indicated by two of the five needles pointing in opposite directions towards the required letters. Requiring five lines instead of two, these earlier models were too expensive to operate over long distances. It is interesting to note that in 1845 the two needle instrument at Paddington was responsible for receiving a message concerning the murder of Sarah Hart at Slough. Her murderer, John Tawell, was arrested in Cannon Street, and later was convicted and hanged. The instrument used for the reception of the message can be seen at the Science Museum today.

The laying of telegraph lines for the railway enabled the murderer John Tawell to be caught.

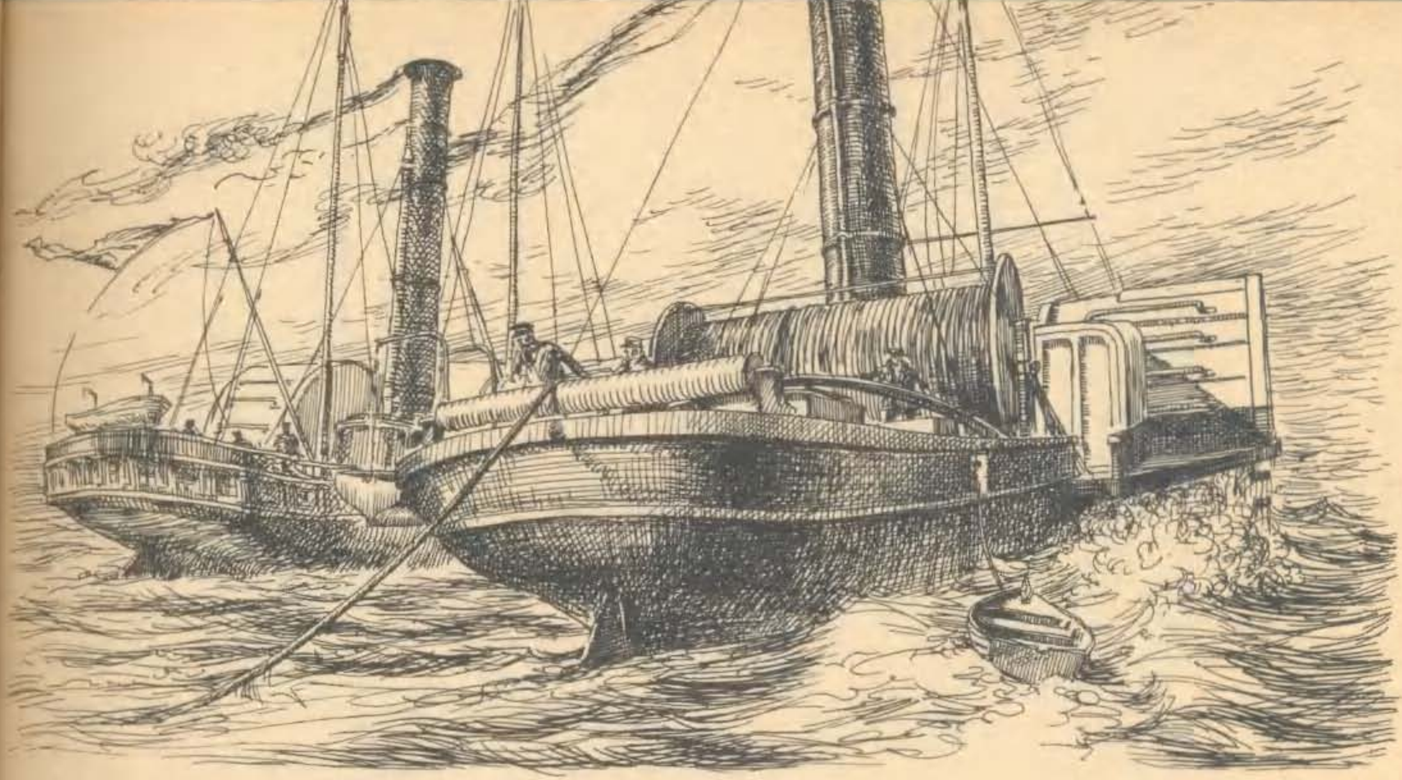
What is it? How did it originate? For this refer to an American artist who displayed an interest in telegraphy. He used his own easel to make the frame of an apparatus which could record signals on paper every time his morse key was pressed, sending a current through his apparatus to actuate an electro-magnet which guided a pencil onto a strip of paper, which passed over a revolving drum. Zig-zag lines were formed which could be read as a coded message. The name of this man was Samuel Morse, and his famous Morse Code was to be used on his own apparatus as well as on other telegraphy machines before being used in wireless telegraphy itself.

Who invented the Morse Code?

The original distress signal CQD, which was followed later by the three dots and three dashes followed by three more dots, standing for the maritime S.O.S., must have saved countless lives after Marconi had made wireless telegraphy possible many years later. Morse received great help from Joseph Henry, another American, who showed him how to increase the range of his telegraphy by means of relay-electro-magnets inserted in the telegraphic line. Samuel Morse suffered hardships and disappointments in much the same way as his predecessors in the field of invention, but finally he triumphed, and before he died in 1871, a network of telegraph wires spread across America carrying messages.



Samuel Morse ingeniously invented an apparatus that could record signals on paper. His famous Morse Code is still widely used.



The steam tug *Goliah* had great difficulties in laying the cable across the English Channel.

Submarine Cables

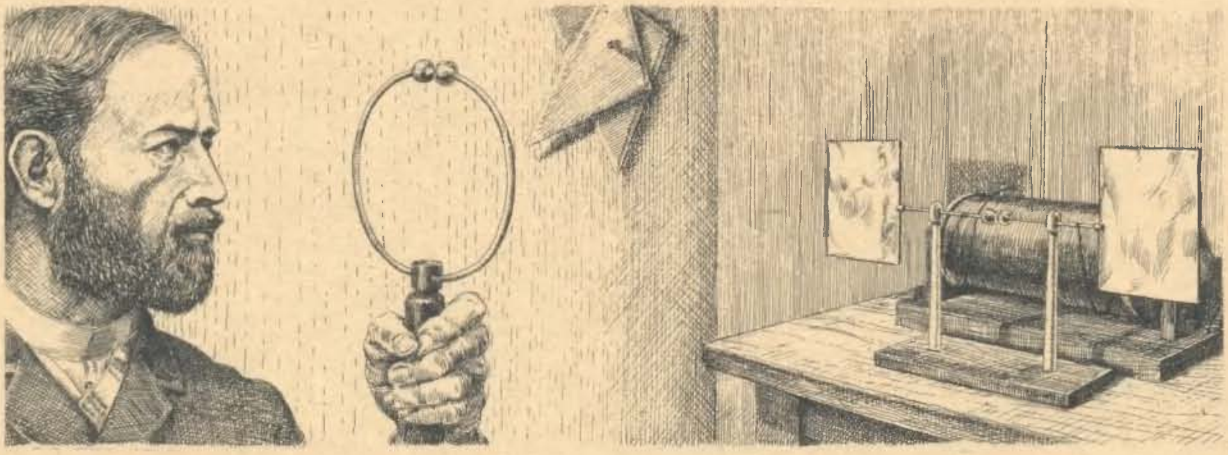
When were the first cables laid?

The first men to lay a cable under the sea from one country to the other were the Brett brothers, John and Jacob, between Dover in England and Cap Gris-Nez in France, in August 1850. The cable was covered with gutta-percha, a substance from certain trees in Malaya which insulated the cable. The action of water actually *hardened* the surface of the material, and gutta-percha was used for many years until polythene sheath took its place.

A steam tug called the *Goliah* was used for carrying the cable, and paying it out across the English Channel, and it was escorted by the survey vessel H.M.S. *Widgeon*. Unfortunately a French fisherman fouled the first cable, but another one was laid in November 1851 which was still in good working order 10 years later.

The first cable across the Atlantic from Valentia Island to Newfoundland was laid by H.M.S. *Agamemnon* (British) and the *Niagara* (U.S. frigate) in August 1888. The line went dead in October that year. Another cable, thicker and stronger than the previous one, was made and was finally successfully laid by Brunel's famous steam ship the *Great Eastern* in July 1866.

The Post Office have three cable-laying ships, one of which is the *Alert*. She is painted a reddish-orange to warn shipping in the vicinity to keep clear of fouling the cable being laid. The modern transoceanic telephone cable is covered in polythene in place of gutta-percha and is of coaxial construction.



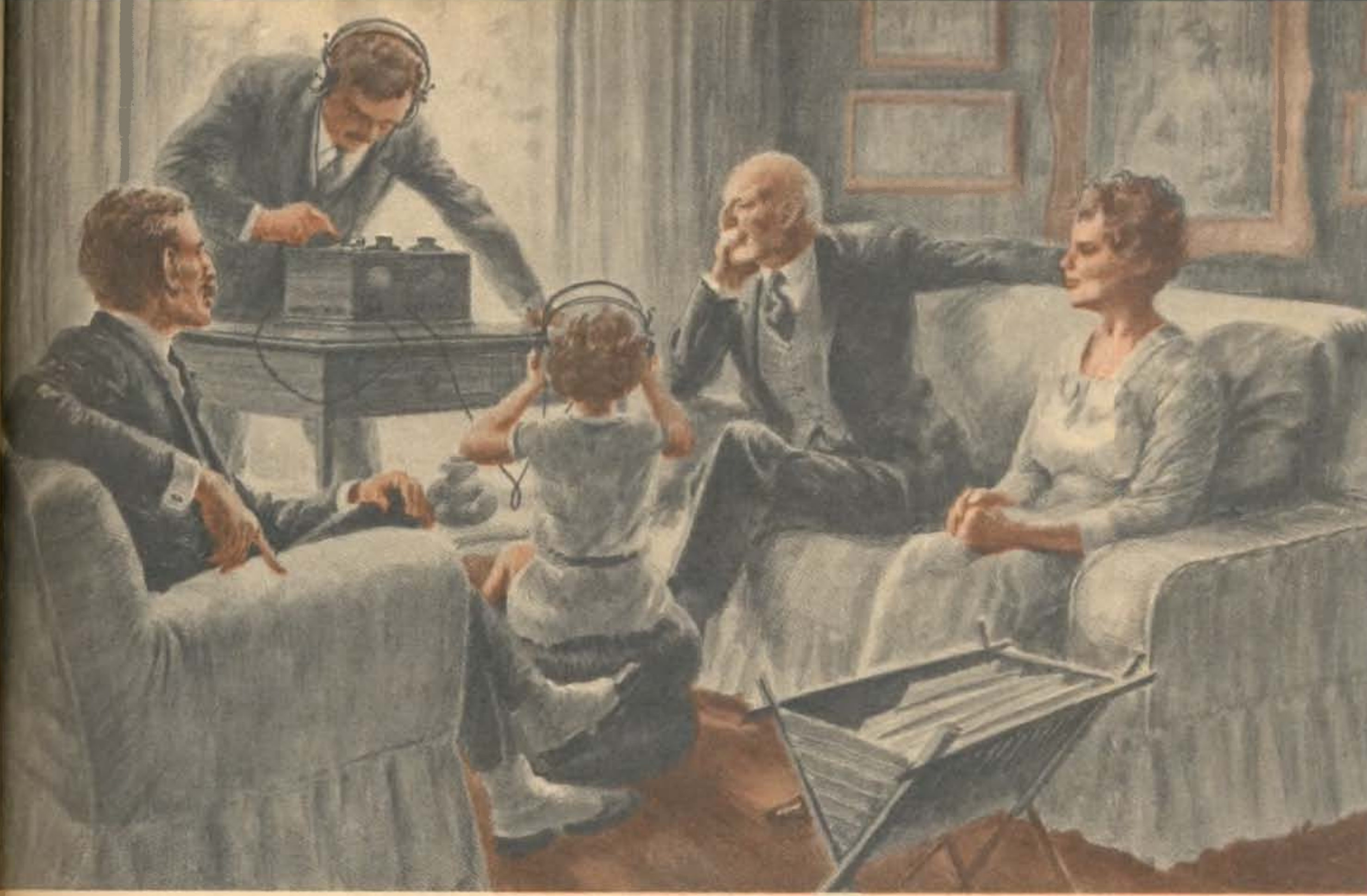
Hertz's apparatus used a Ruhmkorff coil and a secondary circuit to transmit high-frequency oscillations which were detected by sparks on a broken loop of wire.

Radio

Radio has been about the most important discovery in the story of Man and Communication. Because of it man has been able to communicate more speedily over much greater distances than ever before and has been able to do so without the aid of telegraph wires or undersea cables. The discovery of radio was also necessary for your television programmes of today, which require the transference of sound as well as vision from the transmitter to your receiver. Without radio it would have been impossible to keep contact with the astronauts on their journey to and from the moon.

Who were the inventors of the radio?

People equate the name Marconi with the wireless, later called the radio. Marconi was the man who had the great foresight to put many experiments and instruments together to finally produce a commercial proposition over land and sea. We must not forget the many other men who by their experiments and inventions made this possible. As far back as the 17th century Huygens, a Dutch scientist, put forward theories that light was a form of waves in the ether. Later Michael Faraday, Fellow of the Royal Society, endeavoured to prove that lines of magnetic force existed in the ether when an electrical force was applied between two objects. Faraday's pupil, James Clerk Maxwell, proved this mathematically and in 1873 produced a treatise on light and electromagnetic waves. He maintained that it should be possible to produce invisible electromagnetic waves which differed only in frequency from light waves, and which



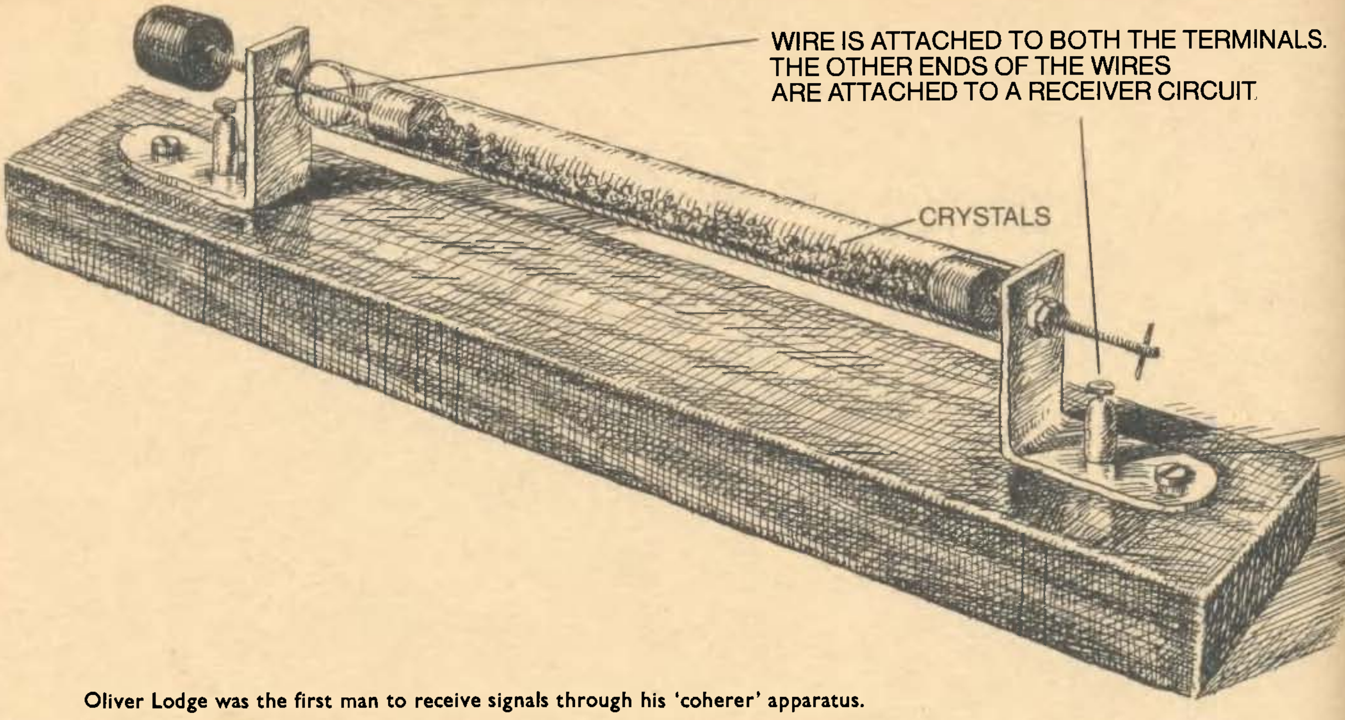
Early radio sets, such as crystals, were equipped with earphones for listening.

travelled at the speed of light, approximately 186,000 miles per second.

How was Maxwell's theory proved?

In 1888, a German professor named Heinrich Hertz proved Maxwell's theory in practice by producing these electromagnetic waves. By using a battery combined with a Ruhmkorff coil he was able to produce a high voltage across the secondary coil sufficient to cause sparks to fly across a gap in the secondary circuit. In order to detect that the electromagnetic lines of force were actually being transmitted he made a circle of wire which he broke at one point to insert a metal ball at each end of the loop. This was his receiver which he held a few feet away from his transmitter. On closing the primary circuit of the Ruhmkorff coil, that is applying power from the battery, sparks flew across the secondary circuit to be picked up by the simple receiver which discharged across the spark gap in its broken circle of wire.

Before Marconi appeared on the scene, William Crookes, knighted in 1897, suggested using electromagnetic waves for signalling.



Oliver Lodge was the first man to receive signals through his 'coherer' apparatus.

What did a coherer do?

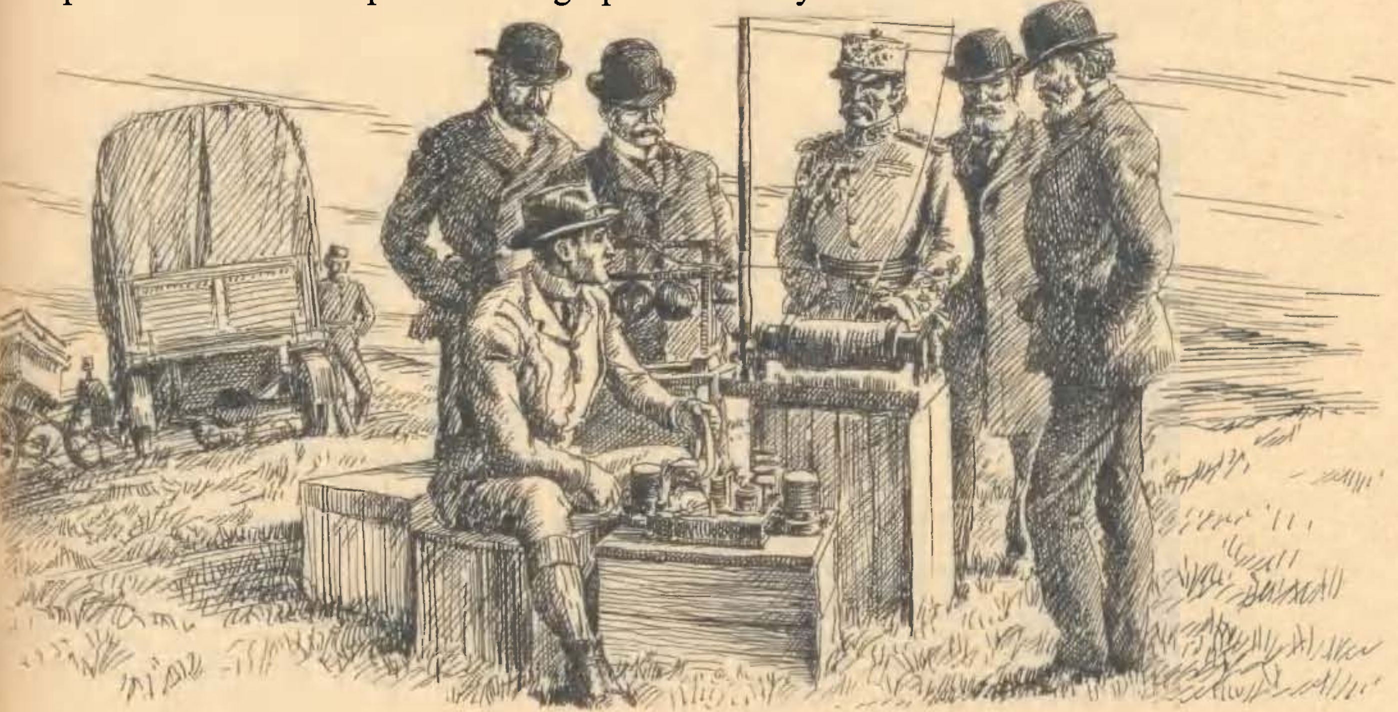
A French professor of physics named Edouard Branly experimented with a glass tube filled with metal filings and found that when a spark was discharged near them, the filings cohered (stuck together), and allowed a current to pass through them.

In 1894, Oliver Lodge, a British scientist, realized that it was possible to use the coherer as a Hertzian wave detector. He named Branly's apparatus a "coherer" and using this and improved coherers of his own, became the first man to receive signals through this type of apparatus. His improved coherer automatically dislodged the filings after a signal had been received, so that the coherer could receive the next signal. By putting the coherer in series with a battery and electric bell it was possible to recognize the presence of the signal by the sounding of the bell. A signal received at the aerial would cause the filings to cohere, thereby allowing the circuit to be closed between battery and bell.

Observe how internationally this great event is building up: Huygens, a Dutchman; Faraday, Maxwell, Oliver Lodge, Englishmen; Hertz, a German; Branly, a Frenchman. Now a Russian appears on the scene, a scientist named Popov. Popov was studying natural electrical discharges in the air, and for this he used an elevated wire. Later Marconi used the same idea for use as an aerial for his receiver and transmitter, to give him much greater range. Marconi also used the American's Morse Code for signalling, with great success. Each man, and many others, contributed something to this gigantic jig-saw, the answers to which were going to spread eventually all over the world and later to the moon and beyond.

What did Marconi achieve?

Experimenting and improving on all the apparatus he could produce and receiving encouragement from another Italian, Professor Righi, who had also worked on the reproduction of electromagnetic waves, Marconi worked at his parents' home in Northern Italy. Using an aerial, induction coil and coherer, de-coherer and spark gap, he managed to bridge a distance of several miles. In 1896 he decided to bring his equipment to England. To protect his invention he first took out a patent. He was introduced to Sir William Preece, Chief Engineer to the G.P.O., who allowed him to demonstrate his apparatus, with success, on the roof of the G.P.O. Headquarters at St. Martin's-le-Grand in London. Sir William Preece himself had been experimenting for some time with the induced current produced between parallel telegraph lines. Later Marconi's apparatus was tried out on Salisbury Plain before important officials from the Post Office, army, navy and government. Amongst the officials was a naval officer named Captain H. B. Jackson, who had also been experimenting with radio. Marconi's experiments were a success and later, on 20 July 1897, he formed his first Wireless Signalling Company. In Italy he managed to make possible radio communication between the land and an Italian warship twelve miles offshore. Back in England the first two permanent shore stations were established with his equipment at Alum Bay, Isle of Wight, and Poole harbour near Bournemouth in August 1898. Ships fitted with his equipment were able to communicate with them. Two more stations, for demonstration purposes, were operated for Lloyds at Ballycastle and Rathlin Island, Northern Ireland, in May 1898.



Marconi demonstrated his equipment before Service chiefs on Salisbury Plain.

When the *Titanic* sank the wireless operator, Phillips, sent out distress signals to the very end.

How did Marconi's equipment save life at sea?

One of the first records of life-saving at sea by his wireless equipment was when the East Goodwin lightship was rammed by the freighter *R. F. Matthews* in 1899. Fortunately, during the previous year both the lightship and South Foreland lighthouse were fitted with Marconi apparatus, which enabled help to be sent to the ship in distress. Range at sea, by radio, was extended to 74 miles, but Marconi, as ambitious as ever, still looked for greater achievements. He needed more capital and in 1900 he changed the name of his company to Marconi's Wireless Telegraph Co. Ltd.

Why was circuit tuning important?

As more and more transmitters were built, both here and abroad, it was found that the sets were not selective enough, too much interference was caused by the broad waveband they used. So Marconi then bought up the patents relating to circuit tuning which Sir Oliver Lodge had previously been experimenting with. Adding his own ideas to improve circuit tuning, Marconi produced, in 1900, his famous "four sevens" patent (British 7777). He also formed an additional company, the Marconi International Marine Communications Company Ltd., with the object of building shore stations first at home and then later abroad. Marconi equipment was rented to shipping companies and trained Marconi operators were supplied to the ships, an arrangement which works to this day. With the success of tuned circuits, which, besides cutting down interference, also increased range, Marconi set about increasing the distance of transmission.

He achieved a distance of about 200 miles, first of all, between a temporary station at the Lizard, Cornwall, and the Isle of Wight station. Encouraged by this, and with the aid of Ambrose Fleming, he built a powerful transmitting station at Poldhu, also near the Lizard. In September 1901, the masts of the Poldhu station were wrecked in a storm, but after being replaced with a simpler aerial, Marconi and his two assistants, Paget and Kemp, took their equipment to Newfoundland and set up a temporary receiving station on Signal Hill, St. John's. For an aerial, to gain height, they used first a balloon, and then a box kite. On 12 December 1901, at 12.30 p.m., Marconi heard through his earphone the pre-arranged signal of three dots, representing the letter "S" in the Morse Code, coming from the Poldhu transmitter over 2,000 miles across the Atlantic. It was fortunate for Marconi that he had Ambrose Fleming as his technical adviser, for Fleming was to produce one of the greatest technological discoveries of our age. Up to now transmitters and receivers had been confined to the use of the Morse Code, or other codes, which were either recorded on an ink printer or read by an operator by the use of a sounder or headphones. This was all very well for the sending and receiving of messages but not for general broadcasting to the public. Before passing on to the next great step in radio discovery let us pause and look back awhile on the practical effect Marconi's radio had on the world and how he and others strove to increase its effectiveness.

Which disaster proved the importance of radios and radio operators?

The terrible disaster of the great British liner, *Titanic*, proved the absolute necessity for carrying radio equipment and a sufficient number of operators to keep watch for distress signals. During that cold night in April 1912, S.S. *Titanic* struck an iceberg and 1,503 people were drowned. The wireless operator, Phillips, continued to send out distress signals using both the old code CQD and the new one, S.O.S., with the result that 705 out of a total 2,208 aboard were saved by the ship *Carpathia* who answered the call. Many more lives would have been saved had the ship *Californian*, which was nearer at the time, had her operator on watch. Unfortunately, he had just completed

an exceptionally long watch prior to the distress calls being sent out. It took time, but in years to come, International Law required constant watch for deep-sea vessels, whether by operators or an automatic alarm system, whereby the transmitted S.O.S. signal would activate the alarm on ships within wireless range whose operators were off watch.

Who was the first murderer to be caught by wireless?

Another great proof of Marconi's successful apparatus was the capture of the murderer Dr. Crippen who was making his getaway aboard the ship *Montrose*. By means of radio, the ship's captain was warned, preventing the criminal's escape. Dr. Crippen, like John Tawell before him, who was apprehended by the use of the electric telegraph, had also murdered a woman, only this time it was the murderer's own wife. Once again justice had prevailed by a few taps on a Morse key. Later, as we shall see, the police would owe much to the assistance of radio.

Radio Telephony and Broadcasting

Who invented the telephone?

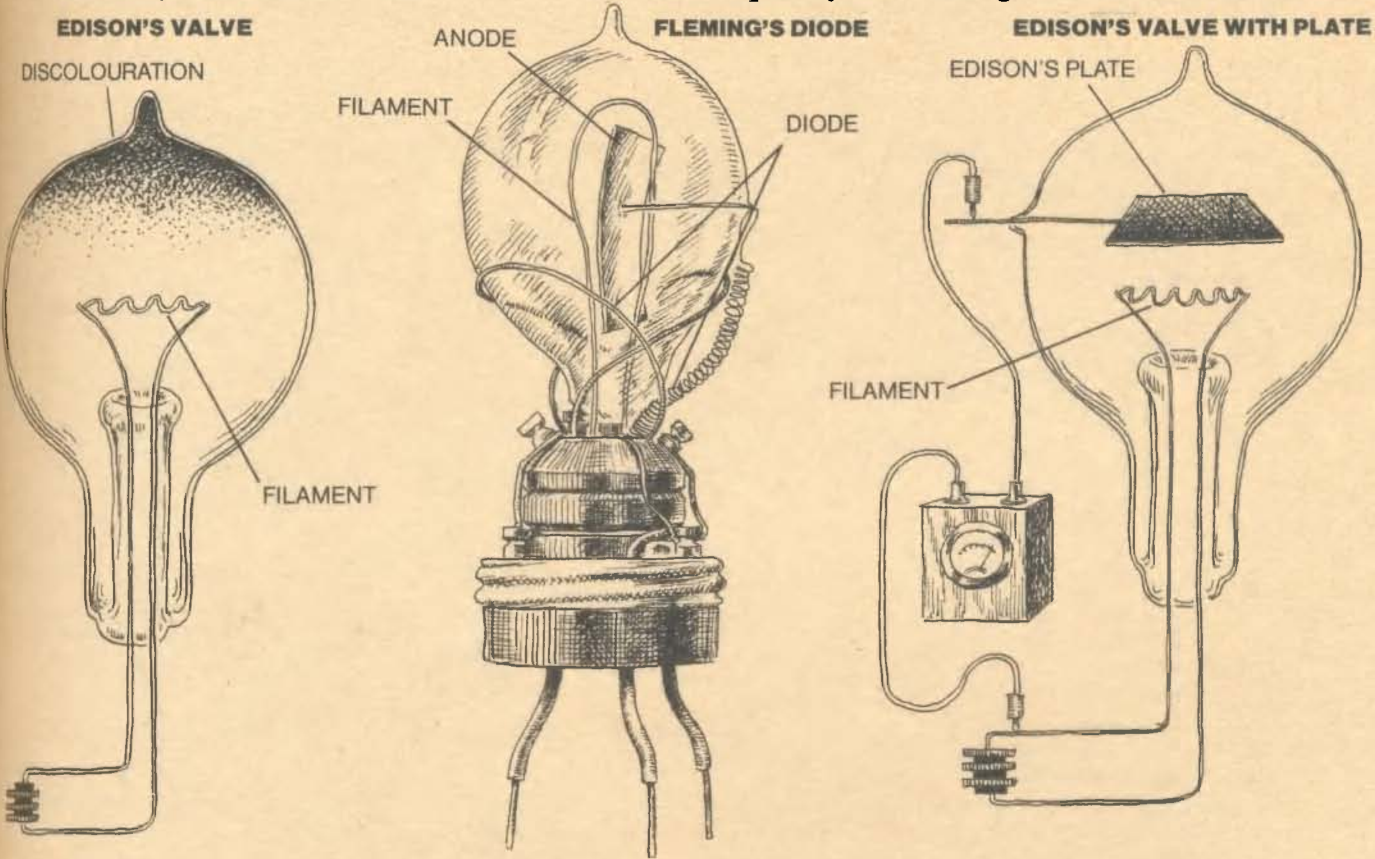
We have seen how communication by radio telegraphy, the use of apparatus capable of sending and receiving the Morse Code, was gradually spreading further and further afield. But man had not properly conquered the ether with his voice. In 1875, a Scot named Alexander Graham Bell, living in America, had invented a practical telephone, whereby man could communicate vocally, but over a land line. Another man, David Edward Hughes, invented a microphone. What was now needed was something to connect microphone and earphone through the ether in the same way that they could be connected by land lines.

In 1902 Professor Fessenden, the Canadian, was working on the problem of superimposing the audio frequency (or speaking waves) on to the high frequency (or carrier waves) which would take the audio frequency wave through the ether to a point where it would be picked up by a suitable detector and turned back into audio frequency waves suitable to be transmitted to the ear via earphones, similar to the telephone earpiece. The waves produced by Marconi with his spark transmitters were totally unsuitable for carrying the audio frequency wave produced by a microphone. What Fessenden wanted was something that would produce an undamped or continuous wave, and he experimented with an arc transmitter with this end in view. He was closely followed by Valdemar Poulsen, a Danish scientist, who also experimented with an arc

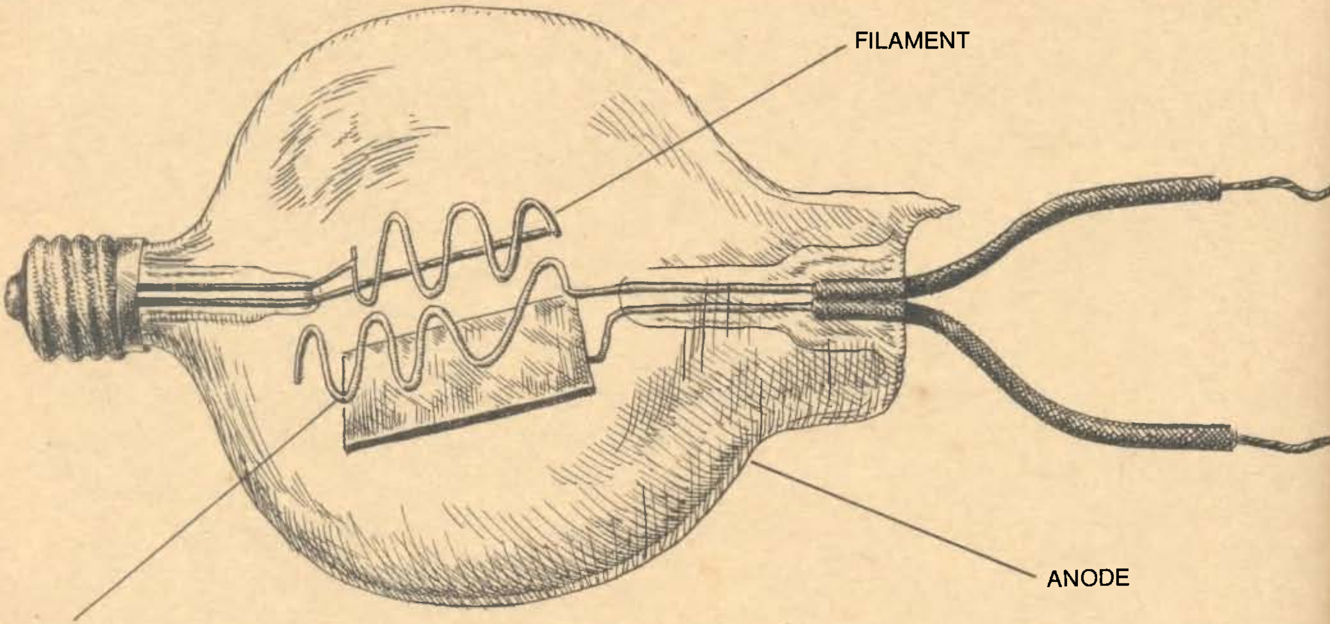
transmitter to produce radio telephony. Fessenden found that the oscillations (the swing between two points) from his arc were too weak, but still working on the problem, he designed, and Alexanderson, an engineer, built a high frequency alternator of sufficient power to produce a carrier wave. On Christmas Eve 1906 wireless operators were greatly surprised to hear speech and music breaking through their watch for Morse Code signals.

What was the "Edison Effect"?

Two years prior to this Ambrose Fleming was considering the curious "Edison Effect". Both he and Edison had previously been concerned with the peculiarities of the electric light bulb. Edison, in America, had found that the carbon filaments used in the bulbs caused a blackening of the glass surface. To try to prevent this he lined the inside of the glass with tinfoil only to find that if he connected this tinfoil to the positive terminal a current flowed between the two, tinfoil and filament. However, on reversing the connections he found that no current flowed. This happened in 1883. In 1904 Ambrose Fleming considered putting this flow of current in one direction to a practical use, and through it he produced the first valve for radio, called the diode—because it consisted of two elements, the filament and the plate (or anode as it is termed today). If current through it travelled in one direction only then here was an opportunity for "rectifying" the high frequency alternating wave into current



Fleming's diode valve and Edison's electric light bulb.



Lee De Forest's audion or triode valve.

pulsating in one direction only. Any variation in the strength of these pulses, if low enough in frequency (such as Morse Code signals or speech and music frequencies), could be used to activate the earpieces of a pair of headphones. Of course the signals would be weak, and a great deal would have to be done to amplify them, both in the construction of the valve and improvement to the circuit. Yet another detector was discovered, this time by H. C. Dunwoody and G. W. Pickard, who found that by touching certain crystals lightly with a wire they would rectify radio signals, that is turn alternating high frequency currents into unidirectional currents.

How were signals amplified?

It was left to an American, Lee De Forest, to find a way of amplifying (strengthening) the signals, which the other detectors all failed to do. To achieve this he experimented and found that by inserting a "grid" between the cathode, the negative pole of current, and anode, the positive pole, and by applying a weak signal to this he was able to amplify it. The charge on the anode was positive. By making the grid positive he found that it helped the flow of electrons from cathode to anode. By giving the grid a negative charge it reduced the anode potential, as it acted as a barrier to the flow of electrons from the cathode. The grid then formed a control of the flow of electrons from cathode to anode. This method enabled him to decrease or increase (amplify) the incoming signals. Lee patented his "audion" valve, as he called it, in January 1907. Today we call a three electrode valve a triode, but it is a much more sophisticated valve than the one Lee Forest made.

In 1913 another brilliant discovery was made, that this triode could be made to oscillate, that is to produce undamped waves which could be used for transmission. This meant that later the large arc and other high frequency transmitters could be replaced by much smaller valve transmitters, having the same, if not greater range than their predecessors. After the First World War, broadcasting to the public was being seriously considered both in Great Britain and in the U.S.A. Both countries forged ahead, with the difference that whereas in America there was little or no control, in Britain broadcasting was subject to strict licensing by the G.P.O. Even to this day a wireless operator is not allowed to operate aboard ship without a licence issued by the Postmaster General, and neither is an amateur, or "ham", as he is known, allowed to operate his transmitter without a licence.

What important discovery led to the wireless?

In America, Dr. Frank Conrad was using gramophone records over his experimental radio-telephony station, which was listened to by people with crystal sets. In England, Captain Round of Marconi's was also engaged in radio-telephony, and in 1920 test transmissions from Chelmsford were received across the Atlantic. In England, the 15 kilowatt station at Chelmsford broadcasted mainly news items and music. Dame Melba, the singer, on one occasion broadcasted "live" on this early system, with a microphone consisting of a carbon earpiece and a trumpet fashioned from a cigar box. The result was so encouraging that another station, 2MT, was installed at Writtle, just outside Chelmsford. The east coast area, being flat, was found

Dame Melba singing into an improvised microphone which was partly made from the wood of a cigar box.

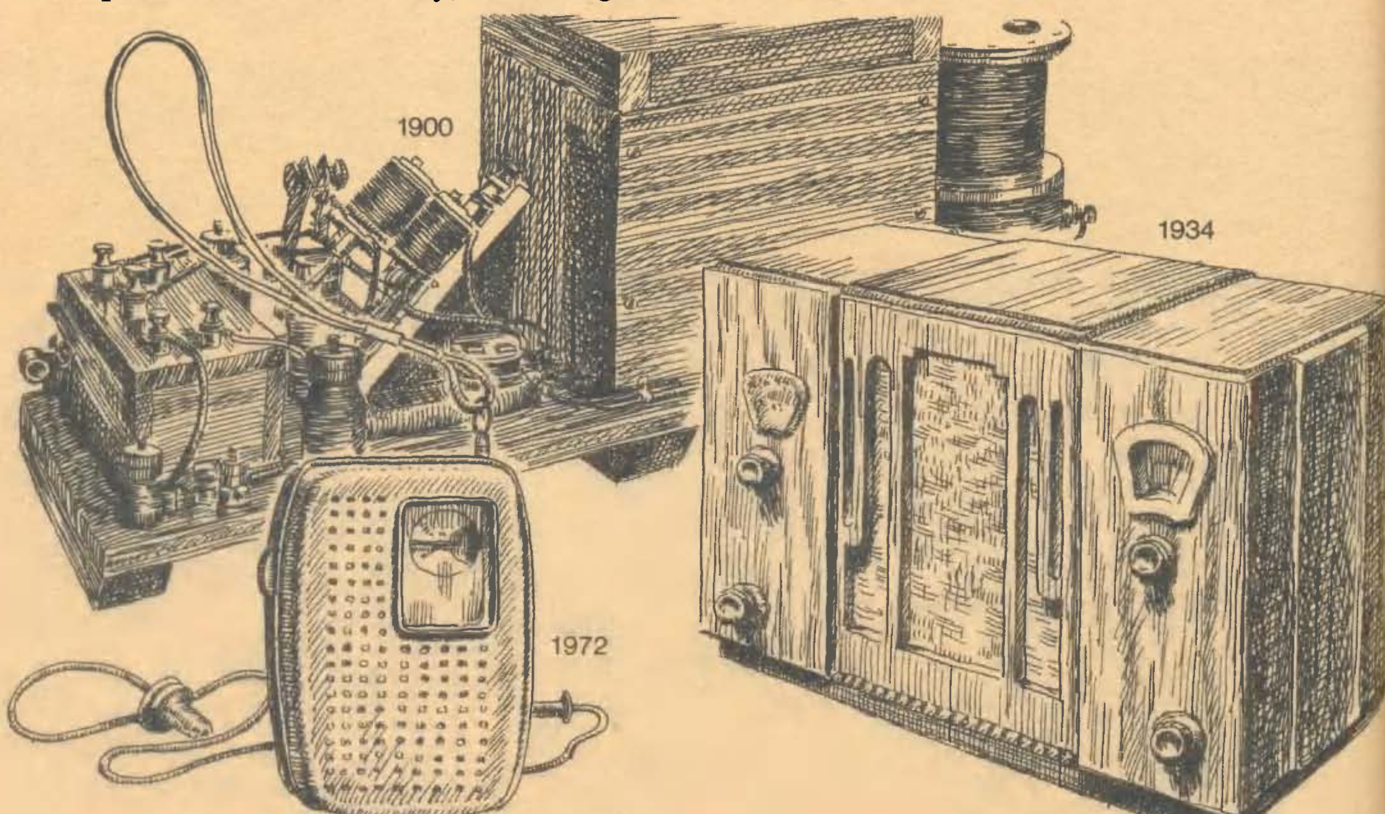
W.–COM–C

most suitable for broadcasting. In Chelmsford itself is the original building, the first of its sort for manufacturing wireless sets in the world, and a commemorative plaque is on its outside wall. Times change, modern buildings are now used for the manufacture of wireless components and the old building is now a furniture store for a well known removal firm.

Captain P. P. Eckersley played an important part in the operation of 2MT and later became Chief Engineer to the B.B.C. which was formed in 1922 from the many firms that started manufacturing wireless sets. To serve a wider area, another station, 2LO, was erected at Marconi House in the Strand, London. Afterwards, the B.B.C. erected eight medium wave stations at different points in the country, retaining the long-wave high-power station at Chelmsford

How did wirelesses change?

Receivers at first consisted of crystal sets with headphones, then gradually valve sets powered by batteries and fitted with loudspeakers appeared on the market. The early speakers were like enormous horns or ear-trumpets placed on top of the sets. The early sets preceded the more sophisticated models of today, mains sets, where one only has to connect the set to the mains and push a button to turn the set on. The old battery sets required three sets of batteries: a high tension of 120 volts connected to the anodes of the valves; a wet accumulator, low tension, of 4–6 volts, to heat the filament; and a dry battery of 9 volts, for the grid bias.



Three wireless receivers—from the earliest to the present day.

Transistors

To deal effectively with the subject of transistors would require a book of its own. They were invented by three Americans, Bardeen, Brattain and Shockley, while working for the Bell Telephone Company, in 1948.

Transistors are very small and have the advantage over thermionic valves that, having no filament to heat, they operate instantaneously. They function with a battery of considerably less voltage than a high tension battery required for thermionic valves, and these batteries are also longer lasting. Like the portable transistor radios of today, the batteries in the early models had to be replaced when worn out. What was more, in these early models the accumulator had to be re-charged, which was a messy business as it contained dilute sulphuric acid which would burn material if it was exposed to it. Transistors are now used in both radio and television and many other electronic devices, such as record players and computers.

Early transistors worked on the principle of two wires pressing on a flat piece of germanium. Although perhaps an improvement on the old "cat's whisker" galena crystals, this point of contact method was not efficient and was subject to noise effects.

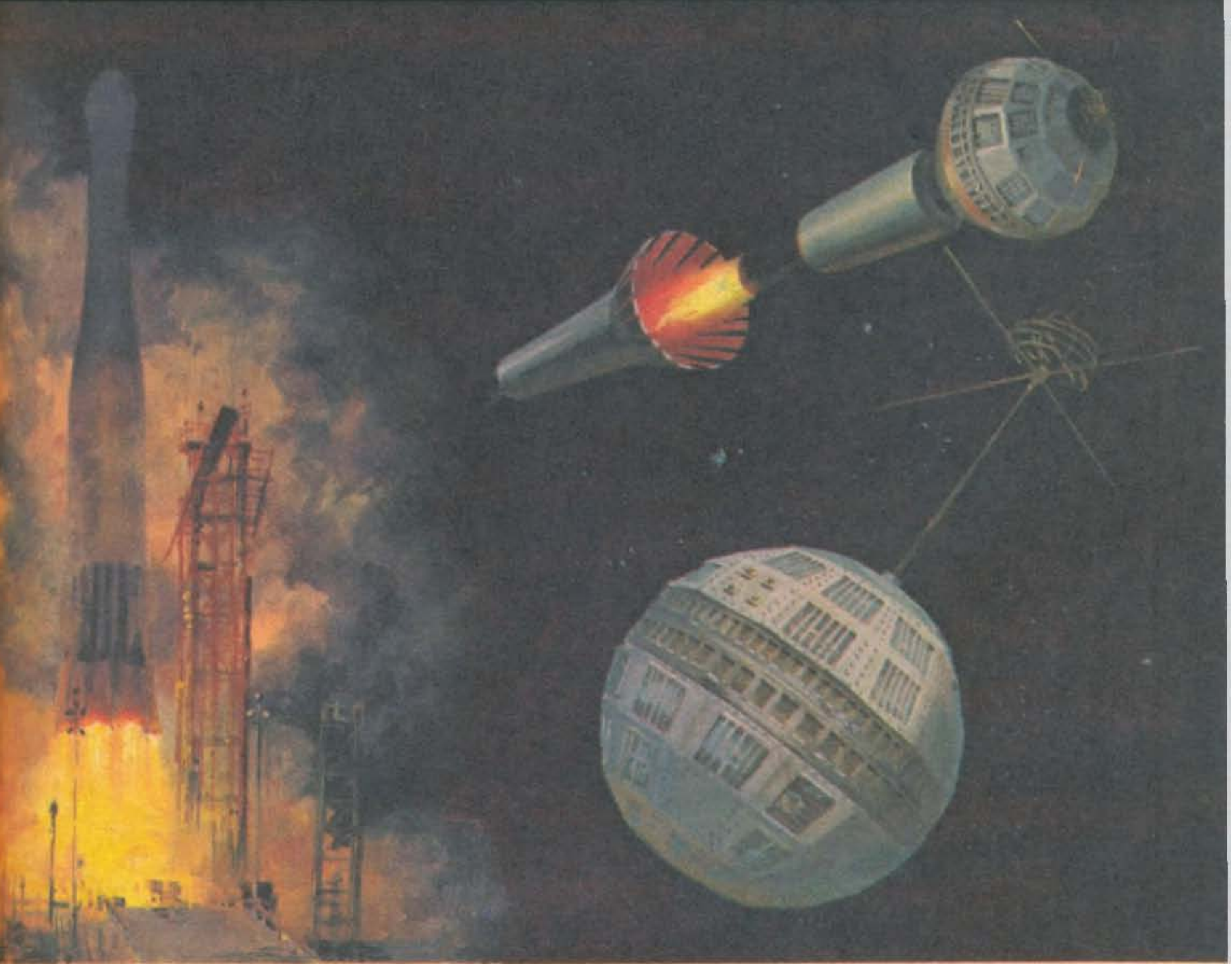
To begin to understand the working of a transistor one must know the meaning of a semi-conductor, which is a material, usually germanium (taken from coal) or silica (taken from sand), which has a resistance between that of an insulator and that of a conductor. In other words, it will not pass current easily. However, by adding certain impurities to it, in a particular way, the number of free electrons in the semi-conductor either becomes less (making it P-type material) or is increased (making it N-type material) according to the substance added to it. By fusing together, in a special manner, a piece of N-type and a piece of P-type material, a flow of current will occur, basically in one direction through them. We have here the equivalent of the diode valve.

Like valves, the conventional transistor has three electrodes, an Emitter, a Base, and a Collector. Although these three electrodes do not operate in the same way as the Cathode, Grid and Anode of the triode valve, they resemble their function, namely the control of electrons to detect and amplify signals. The transistor using three electrodes (a triple sandwich—P-N-P type or N-P-N type) as compared with the diode's two pieces of material (P-type and N-type) was made and produced in different ways.

One complex method is the Silicon Planar transistor. Here the collector, base and emitter are manufactured in layers. The process calls for very

Transistors can be made so small that they can pass through the eye of a needle.

detailed work, starting with a thin slice of silicon, about 5 cm. in diameter. The surface of this piece of silicon is oxidized, windows are cut into the oxidized silicon, the surface cleaned and an impurity is fused into the silicon to form the base. The surface is then oxidized again, more windows are etched again in the oxidized surface and the emitter plane is diffused into the base. We now have our three electrodes, forming the N-P-N or P-N-P sandwich. Final processing includes the making of electrodes connected to a metal surface deposited through more windows made in the oxidized surface. The piece of silica is now cut up into anything up to 6,000 transistors, each one being tested before being cut by a diamond cutter. We have in effect a means of mass production of transistors of the smallest size imaginable which are then bonded, collector side down, on to a stem or header, which is gold-plated. Gold or aluminium wires are used to connect the base and emitter to the lead-out wires, they are examined, washed



Telstar being launched by a three-stage rocket from Cape Kennedy.

and dried and finally encapsulated.

Planar techniques led to the creation of the integrated circuit in which transistors and components could all be diffused into a piece of silicon small enough to pass through the eye of a needle. This chip, as it is called, can contain as many as hundreds of components, and as an integrated circuit can be used to good effect in radio receivers, amplifying circuits and computers. The integrated circuit shown in the illustration is before encapsulation.

Today modern wireless transmission plays a great part in our lives, and not only for entertainment. With the use of short waves important messages can be flashed around in seconds, not only to other lands at the far corners of the earth but to ships at sea sailing to those lands all over the world. More recently we have seen the advantage of artificial satellites such as Telstar, which give us improved reception not only on this earth but from space craft circulating and landing on the moon as well.

Alexander Graham Bell 'accidentally' calls his assistant by telephone for the first time.

The Telephone and Teleprinter

Who was Alexander Graham Bell?

Alexander Graham Bell, born in Edinburgh in 1847, invented the telephone while in the United States of America in 1875. Interested in music and the human voice, he taught elocution and tried to make a musical telegraph, for which he received financial backing from various Americans. In the course of his experiments he made a mechanical ear, which contained a diaphragm which vibrated when sound waves were impinged upon it. This led eventually to the original telephone earpiece which he and his assistant Watson later perfected enough to make the human voice audible over a land line.

How did Bell accidentally prove his experiment?

The tale goes that while working on his apparatus Bell, thinking Watson was in the room, said "Come here, I want you". Watson came, but only because he was listening

on a vibrating diaphragm in a different room downstairs. Like all inventions the apparatus had to be perfected and then sold to the public. Difficulties, financial and otherwise, had to be overcome. The first telephone company was registered in Britain in 1878, and it opened its London exchange in August the following year, with a handful of subscribers. Fearful of the fate of its telegraph service, the Post Office managed to get a High Court ruling that, for the purpose of the Telegraph Act, telephone and telegraph were the same, and in this way all telephone companies had to operate by licence from the Postmaster General. On 1 January 1912 the G.P.O. took over the telephone systems with the exception of two, owned by the corporations of Portsmouth and Hull. Today Hull and the Channel Islands still run their own services.

What is S.T.D.?

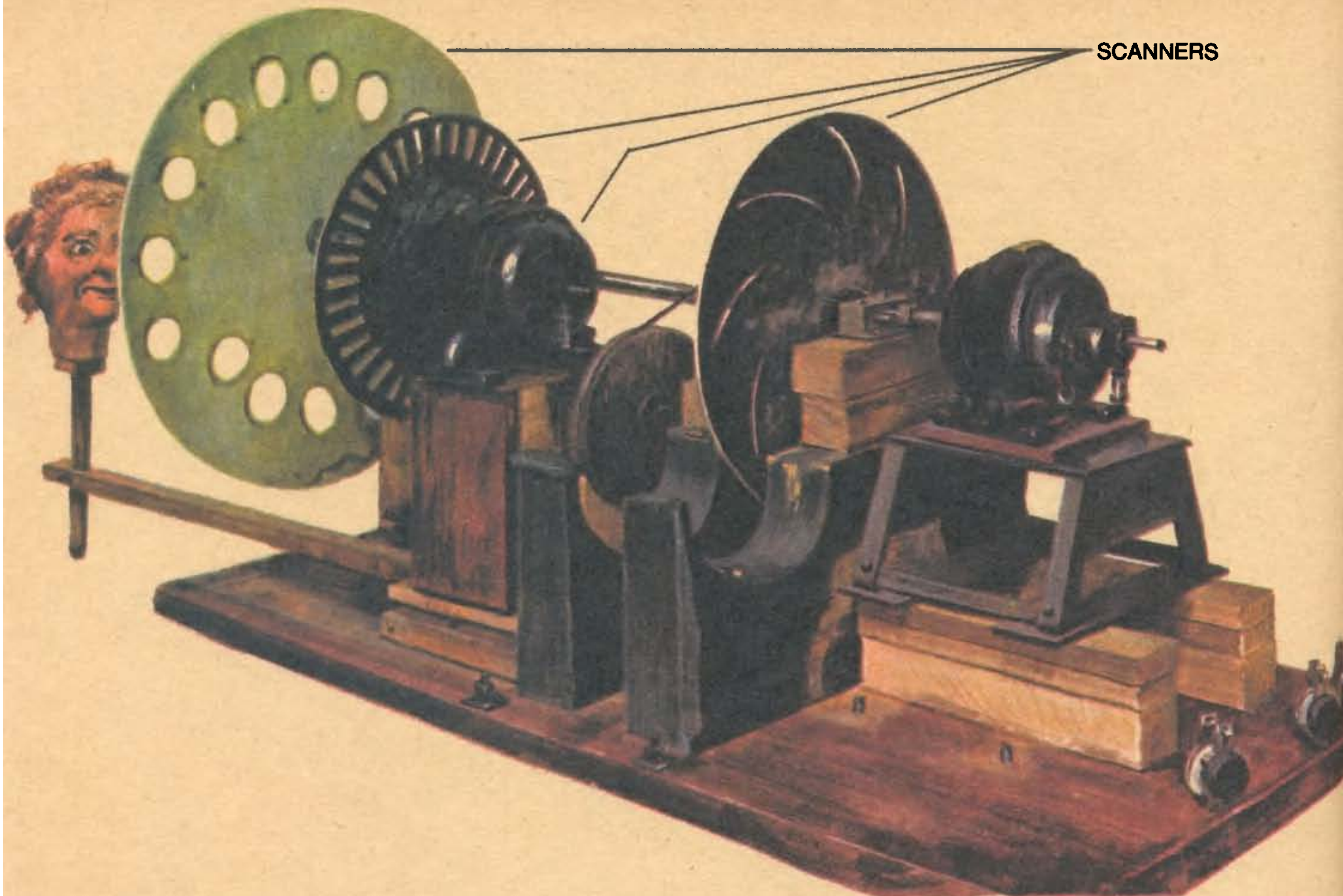
With continual research the Post Office vastly improved telephone communication, both in this country and abroad. Today we have over 6,000 automatic exchanges and around 15½ million telephones operating in Britain. Subscriber Trunk Dialling (S.T.D.), first used in Bristol in 1958, now operates over much of the country and it is now possible to dial direct to Europe and even to North America.

How have telephones developed?

The 620 ft. Post Office Tower built in central London provides inter-city microwave links, saving considerably on many miles of wire for telephonic use. In this way not only are thousands of telephone circuits provided, but many television channels as well.

The original telephones required two wires for conversations between two subscribers. Now, due to such innovations as Carrier Working with coaxial cables and Pulse Code Modulation, it is possible to have a number of telephone conversations carried on simultaneously, using the same conductor.

By the use of cable and wireless, telephone conversations can be carried on over great distances and radio telephony can be used aboard ship and, more recently, in private cars. Taxi cabs, police cars and private aircraft have their own systems contacting them to their respective bases. Radio-transceivers are used in outposts in the outback of Australia and we are all familiar with the famous Radio Doctor who flies from one farm to another because distances between farmsteads are often as much as 100 miles, making communication otherwise impossible. The army and police force find walkie-talkie short wave sets indispensable for their work. Another useful piece of apparatus used by the Post Office is the teleprinter, used for telegrams and now known as the Telex System. Used both at home and abroad each Telex subscriber has his own machine which looks partially like a large typewriter. The message is typed out, after dialling the number of the telex system you are communicating with, and providing the other machine is switched on, the message is received on it whether anyone is present at that end or not.



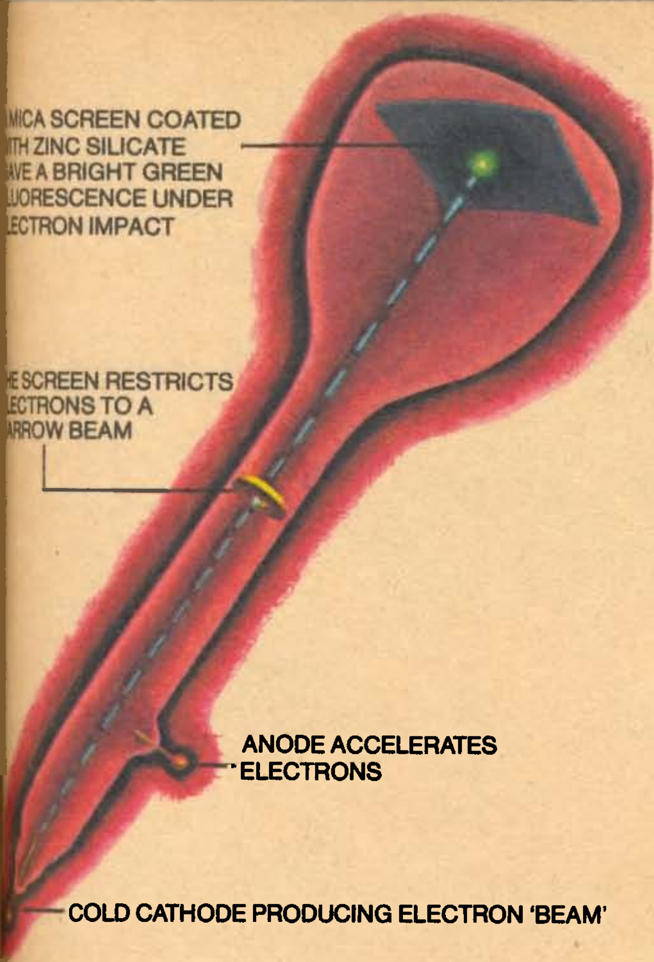
Left—Baird's original scanning machine. Right—Braun's television tube.

Television

The word television came into being when used by the Frenchman Perskyi. He combined the Greek word "tele" (at a distance) with the Latin "video" (I see).

Why was selenium used in television?

In 1884 Paul Nipkow, a German engineer, patented his scanning disc in Berlin, which was later to be used in television to good effect by John Logie Baird, a Scottish inventor whom we shall discuss later. Very briefly, Nipkow's system was an apparatus using a revolving disc both at the transmitter and at the receiver, the one at the receiver being synchronized to follow that of the transmitter to produce the same picture. Into the disc he cut a spiral of holes so that as the disc turned before the object or scene to be transmitted each hole traced another line of the scene. In one complete revolution the scanning was completed. Nipkow's scanning was exposed to a selenium screen. Selenium, it was found, had the property of varying its resistance to the flow of current according to the amount of light shining upon it. In this way, degrees of light and shade of the scene to be televised could, by reason



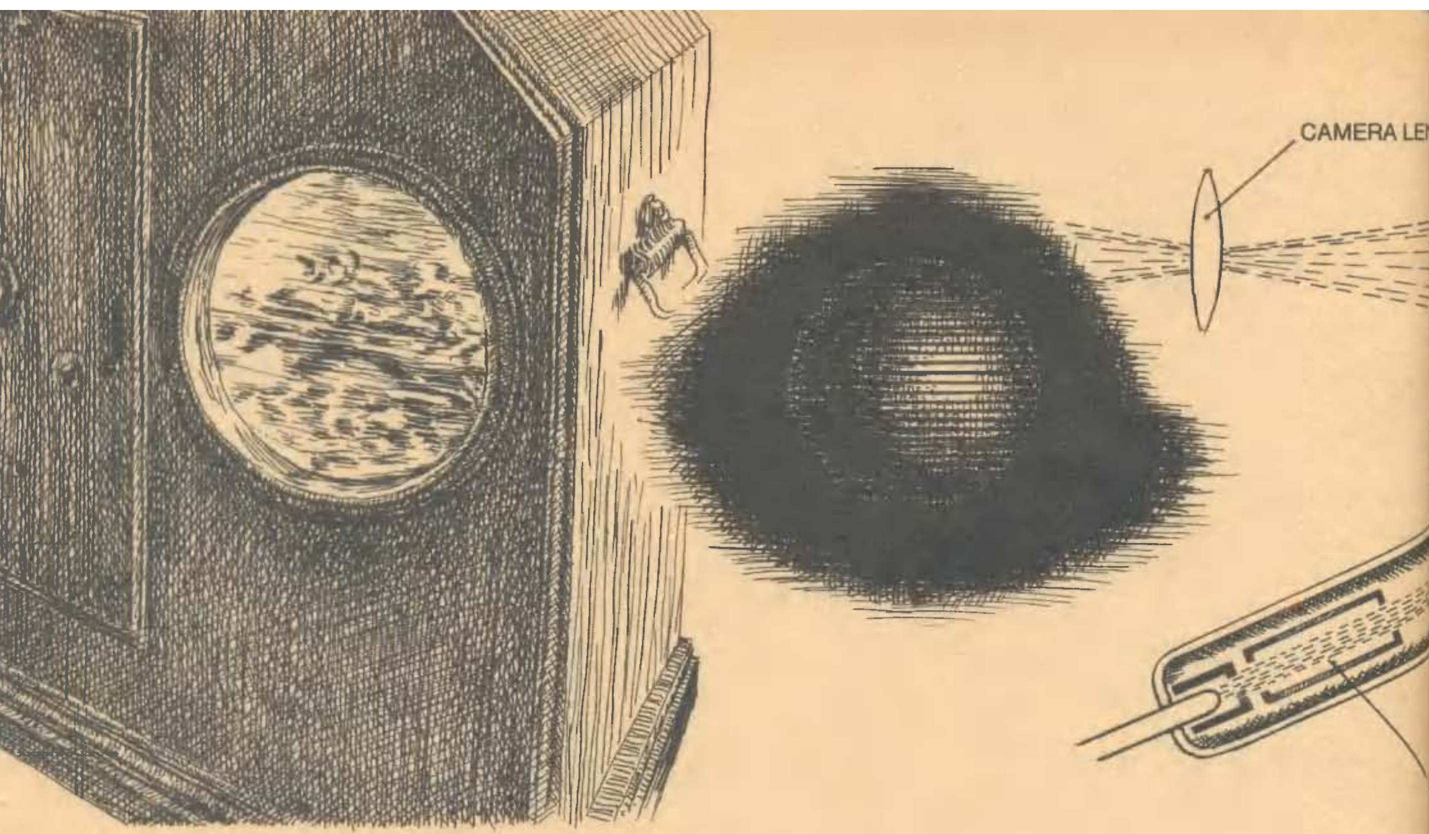
of the selenium, affect the strength of signals transmitted. At the receiver the signals could then be changed back again into a picture of the scene transmitted. In practice, selenium was too sluggish to be effective. Later other photo-sensitive materials were used, which actually produced currents when subjected to variations in light. Nipkow's experiments were confined to a telegraph line. Later television, like radio, was to be transmitted through ether.

What is a Cathode Ray Tube?

Over a hundred years ago Julius Plucker, an American, thought of using an evacuated glass cylinder with an electrode at each end, a cathode negatively charged, and an anode (or plate) positively charged. The glow produced on the side of the cylinder when a potential (electrical pressure) was applied to the cathode, Plucker referred to as "Cathode Rays". In 1869 another man named Hittorf discovered that by placing an electrode in front of the cathode a shadow was produced on the side of the tube when a current was applied to the cathode. Later Sir William Crookes made the electrode in front of the cathode in the shape of a Maltese Cross which produced a shadow of its shape on the side of the tube when a potential was applied to the cathode. What did all these experiments show? Namely two things: that there was an electrical flow between the two electrodes; and that by placing a third element in the path of the electrons a shadow could be obtained.

How was the C.R.T. improved?

In 1897 Professor Karl Ferdinand Braun, Austrian physicist at Strasburg University, improved Sir William Crookes, cathode ray tube (C.R.T.) in several ways. He placed at the thick end of the tube (opposite the cathode) a mica screen coated with phosphorus, which would fluoresce when bombarded with electrons emitted from the cathode. The screen was protected by a glass front through which one could see the fluorescent glow. Another scientist, Ryan, found that by putting electromagnetic coils around the neck of the tube; by means of varying the current flowing through the coils; and by varying the position of the coil itself, he was able to spotlight the beam



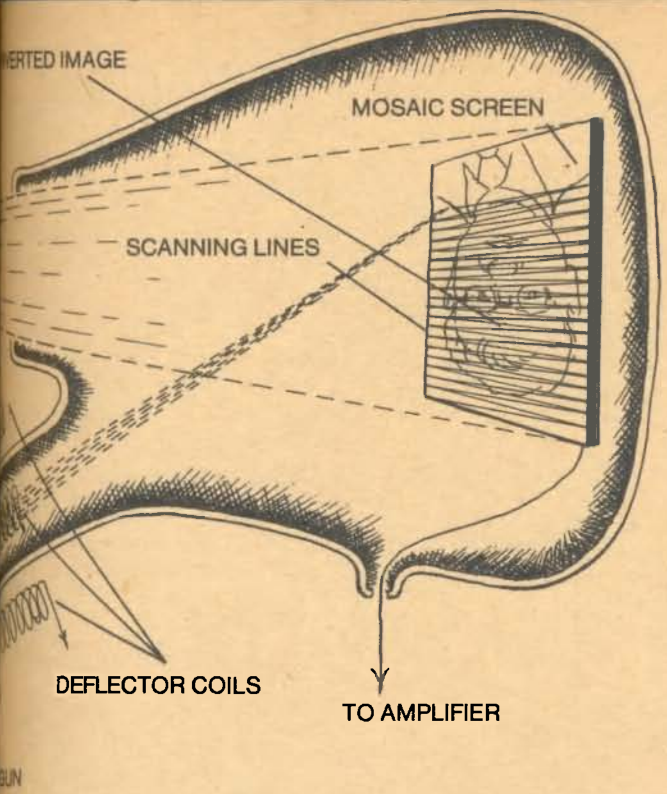
Baird was the first man to broadcast the Derby in 1931—the picture was very wobbly.

on the screen to a far greater degree of accuracy than could Braun. The C.R.T. was further improved by a man named Wehnelt, who by coating the cathode with an electron emitting oxide and by heating it, produced a much brighter spot on the screen. In 1907, a Russian, Boris Rosing, built a television set for display purposes. He used a C.R.T. for the receiver and a mirror type of scanner for the transmitter. But the whole system lacked amplification for practical use and once again the selenium, the key to the early experiments, was found to be too sluggish.

The following year, 1908, an Englishman by the name of A. A. Campbell Swinton, who was an electrical engineer, put forward the idea that a C.R.T. should be used at the transmitter as well as at the receiving end of transmission. Later, in 1911 when he was President of the Rontgen Society, he suggested that the transmitting tube should be evacuated of all air, and that the scene to be transmitted should be exposed to a mosaic screen of rubidium, which would produce the necessary charges for transmission of the object televised. It was many years later before this excellent theory was put into practice.

Who first broadcast the Derby by television?

In 1923, the celebrated John Logie Baird appeared on the scene. An intrepid inventor, and a tenacious Scot, we see him in his small room at Hastings using odd bits of wireless and other materials, together with the head of a ventriloquist's dummy as his model. He favoured the rotating disc as a means of scanning, and he was the



A section of a modern television camera to show how it works.

first man to actually broadcast for the B.B.C. experimental programmes in 1929 and 1930. He was the first man to broadcast the Derby in 1931 and in 1932 with improved pictures on a 8″ × 10″ screen scanning 30 lines. This couldn't have been anything like as clear as the 405 lines and the 625 lines used today.

How is the picture formed?

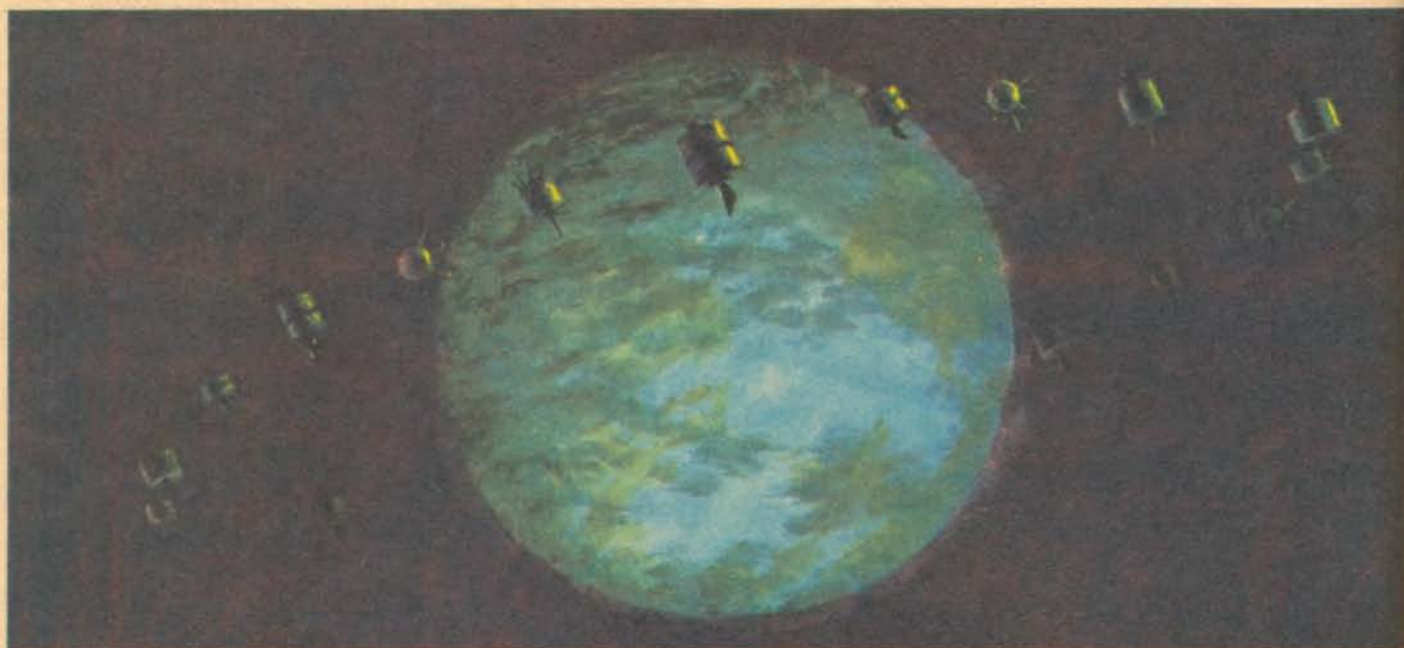
If you look at your present screen you will see the picture is composed of a number of lines, created by a single spot of light which is travelling so fast that it gives the appearance of lines, which in turn are scarcely visible if they are properly controlled to give a complete picture. That single spot of light is created by electrons being shot from the cathode of your tube, which in turn is receiving signals from the transmitter. It all happens so quickly that all you see is the completed picture. As we read, as far back as in 1908, A. A. Campbell Swinton had advocated using cathode ray tubes in both transmitter and receiver. In America, Vladimir Zworykin had patented an electronic camera tube, called the Iconoscope, which was part way to achieving this idea of Swinton's. In 1932, Sir Isaac Schoenberg, Director of Research of the Electrical and Musical Industries (E.M.I.), with his team produced the Emitron Mark I camera tube. In March 1934 it was agreed to form a company between Marconi and E.M.I. and it became known as Marconi–E.M.I. Co. Ltd. They produced television cameras using the electronic gun as compared with Baird's mechanical screening.

Very briefly, the television camera works on the principle that the scene televised is exposed, through the camera lens, to the screen consisting of a mosaic of photo-electric silver-caesium cells, which takes up a charge when subjected to the varying degrees of light from the scene to be televised. These charges are released for transmission by being subjected to a stream of electrons from the electronic gun which scans continuously the mosaic screen, in the same way that the screen of your receiver is screened.

Why was Marconi's system superior to Baird's?

In the same year, 1934, a select committee was set up by the Postmaster General, with

Lord Selsdon as chairman. Their purpose was to report on the quality of the television systems being developed at that time. In 1935 it was found that Baird's system used 240 lines with 25 pictures a second, whereas the Marconi–E.M.I. used 405 lines, with 25 pictures a second, and that the pictures produced by the latter were superior to the former. In August 1936, both systems broadcasted on the occasion of the Radio Exhibition at Olympia. Later that year, in November, the Postmaster General opened Alexandra Palace Station, and in February the following year he announced that the Marconi–E.M.I. system had been recommended for public use. Although closed for the duration of the war, television became popular soon afterwards and more recently colour television as well.



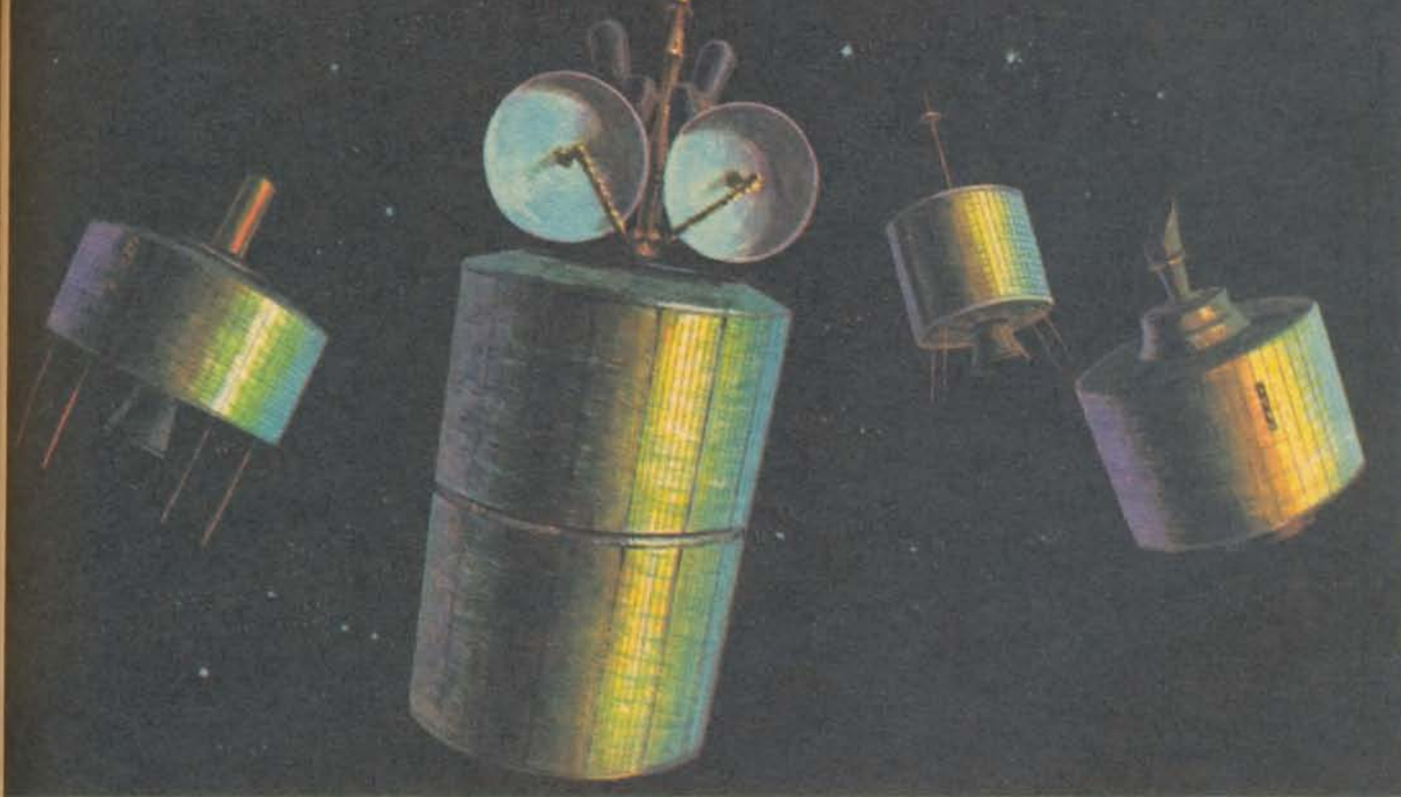
Many satellites have been launched, and even when they have stopped transmitting they remain in orbit around the earth.

Communication by Satellite

Who thought of a communications satellite?

In 1945 an Englishman named Arthur C. Clarke put forward the idea of manned satellites for communication, advocating that they be placed in synchronous orbits, synchronizing, that is, with the movement of the earth. In this way the artificial satellites would in effect be in a continuous position over the earth and messages sent to them would be received and re-transmitted by the operators aboard to other earth stations within range of the satellites.

An American scientist, John Robinson Pierce, suggested ten years later using unmanned satellites, passive and



There have been four different Intelsat satellites launched. From left to right—Intelsat II; Intelsat IV; Intelsat I; and Intelsat III.

active, circulating in synchronous and random orbits.

Why use an artificial satellite?

It was found that the micro-wave frequencies used by the early satellites were more stable than long distance communication by short wave ground stations. A satellite acting as a relay station far above the ionosphere covers a far greater area and a greater distance than any method yet used. Its signals penetrating the ionosphere are unaffected by its changes, which would affect lower frequency signals. Once the satellite is launched, this form of communication, used internationally, can be cheaper and more reliable than other systems.

Before the satellite can commence operating it has to be launched thousands of miles into space. This is achieved by means of a giant rocket, which in different stages, usually three, carries the satellite up to the required height and position and releases it to be sent in orbit around the earth. Once in orbit it is controlled from base and can be used for sending radio, television or telephone signals to any part of the globe in range and suitably equipped with special aerials to receive such signals.

What is the difference between active and passive satellites?

There are, as already stated, passive and active satellites. Passive satellites, such as Echo I launched by the United States in 1960 and Echo II launched in 1963, had no means of re-transmitting signals, but owing to their surfaces, reflected the signals back to earth. Not having any working parts these satel-

lites could not be controlled from base, after launching. The advantages of passive satellites are that there is little to go wrong with them, until they cease to function altogether; they do not have to be energized as active satellites are, and they are able to reflect signals from a number of ground stations simultaneously. They do, however, have to be big. Echo I was a 100 ft. diameter plastic balloon thinly coated with metal. After a time it became punctured and torn by particles in space. One of the principal disadvantages of passive satellites is that they require much stronger transmitting signals and very sensitive receivers on earth to operate satisfactorily.

Active satellites, on the other hand, carry both receiver and transmitter. They receive signals, sent from specially beamed aerials on earth, and then amplify them and transmit them back again to other earth stations. To do this they receive their power from solar cells exposed to and energized from the sun.

How do satellites orbit the earth?

Before considering any more individual artificial satellites let us consider the orbits in which they operate. Satellites travelling at random orbits are usually used in conjunction with other satellites. As the name suggests, they orbit at random, independent of the world's rotation. Spaced apart, the satellites are followed by earth stations, receivers and transmitters, until one satellite passes over the horizon, then the transmitting beam is switched to the following satellite in range, and so on to prevent break in transmission and reception. A satellite can only serve one third of the earth's surface at any one time. For this reason transmitting and receiving stations have to point their aerials directly at the satellite as in the case of the Post Office ground station at Goonhilly Downs in Cornwall.

Synchronous orbiting satellites, however, have the advantage of following the earth's rotation with a single orbit, and in effect remaining in a similar spot over the earth's surface. To achieve this they have to be launched into a very high orbit over 22,000 miles above the earth's surface. Three such satellites suitably placed can connect practically any two places in the world.

Which important satellites have been launched?

Let us now consider individual satellites. It would take too long to enumerate them all, but let us consider a few and their earth communicating stations. The American Telephone and Telegraph Company working in conjunction with N.A.S.A. (National Aeronautics and Space Administration) produced the world-famous Telstar satellite, which was launched in July 1962, being placed in orbit by a Delta rocket. Many television programmes were exchanged between the U.S. and Europe both in colour and black and white. It was also used for telephone calls either way and for relaying photoprints. Damage by radiation to its transistor circuits was detected by earth control, and it went silent on 21 February 1963.

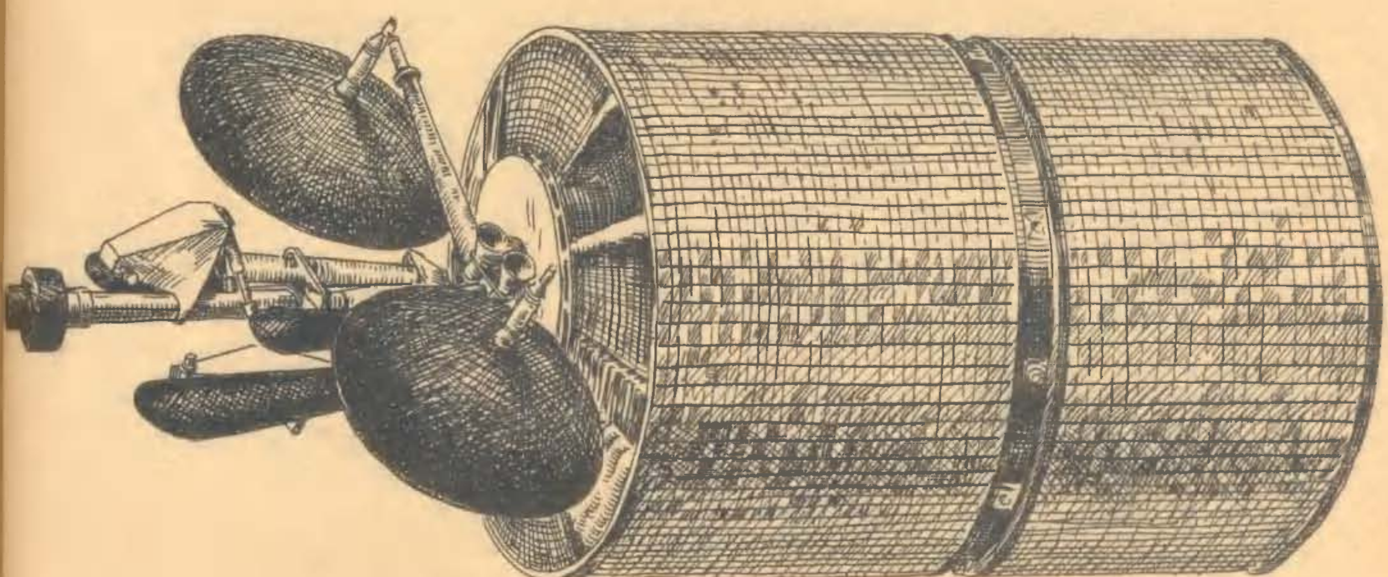
Telstar II was launched on 7 May 1963, with improved design to resist radiation. The first commercial satellite Early Bird was launched in April 1965. Remaining in one spot over the Atlantic it carried 240 telephone channels and could also broadcast television between the United States and Europe, and more recently, with two other satellites, one in the Indian Ocean and one in the Pacific, we are able to receive television signals from Australia in Great Britain. Russia orbited her first communications satellite, Molniya, in 1965.

When were the Intelsat satellites launched?

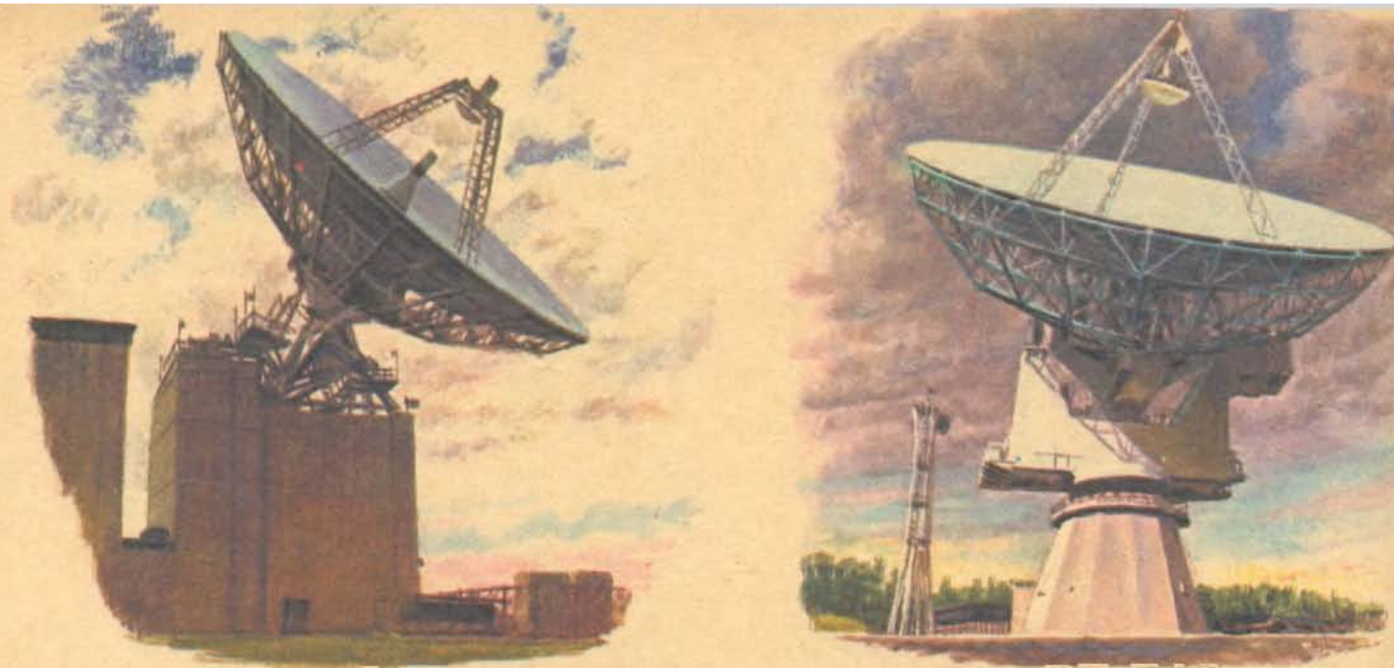
Following Early Bird, which was also known as Intelsat I, were a series of other Intelsat satellites launched by N.A.S.A. for Comsat (Communication Satellite Corporation) on behalf of Intelsat (International Telecommunications Satellite Consortium), the last named organization being a collection of 81 (to date) different nations owning the satellites which now cover the globe with a commercial communication system by satellite. The first successful Intelsat II was launched and placed over the Pacific Ocean on 11 January 1967 and connected North America with Australia and the Far East.

Intelsat III was launched over the Atlantic in September 1968, and another successful Intelsat III was launched over the Pacific in May 1969 which later was moved in June of that year to over the Indian Ocean.

The 25 January 1971 saw the launching at Cape Kennedy of the biggest communications satellite in the world, at that date, Intelsat IV. Built by Hughes Aircraft in America, measuring $17\frac{1}{2}$ ft. high by 7ft. 9in. in diameter, this most sophisticated communications satellite was made to



The biggest communications satellite yet launched is Intelsat IV.



Two earth stations: left—Moree Ground Station in Australia; right—Warksworth in New Zealand.

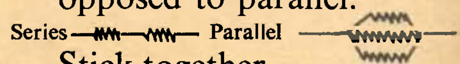
cope with 9,000 two-way telephone conversations or to transmit 12 simultaneous colour television programmes or a combination of these at the same time. It possesses six antennae (aerials), two global for receiving, two global for transmitting and two for spot beam transmitting.

In the last week of February 1972 the third Intelsat IV communications satellite televised the historic visit of President Nixon to the People's Republic of China, and people of the Western world were able to see his meeting with Chairman Mao. As the number of satellites increases so does the number of earth ground stations all over the world from America to Japan.

By exploring outer space and by making use of the knowledge attained man can now communicate with his fellow man, both audibly and visually, in split seconds, from one end of the world to the other by means of artificial satellite, television and radio. In this way we are nearer to those in foreign lands than ever before.

Glossary

Series	Direct connection, as opposed to parallel.



Cohere	Stick together.
Condenser	A component capable of storing electricity.
Conductor	Substances which will carry electrical current, such as metal, wire, etc.
Current	The flow of electricity measured in amperes.
Frequency	Number of cycles of alternating current per second.
Insulators	Substances which will prevent the flow of electric current.
Voltage	Electromagnetic force, measured in volts.
Watts	Unit of electric power. Kilo-watt (1,000 watts).
Wavelength	Distance between the crest of one wave and another. Shown by the symbol λ.

HOW AND WHY

These books answer the questions most often asked about science, nature and history. They are presented in a clear, readable style, and contain many colourful and instructive illustrations. Readers will want to explore each of these fascinating subjects and collect these volumes as an authentic, ready-reference, basic library.

TRANSWORLD PUBLISHERS LTD., CENTURY HOUSE,
61/63 UXBRIDGE ROAD, EALING, LONDON W.5 5SA